PB83-117366

Acid Rain Mitigation Study. Volume II
FGD Cost Estimates (Appendices)

Radian Corp.
Austin, TX

Prepared for

Industrial Environmental Research Lab.
Research Triangle Park, NC

Sep 82

U.S. Department of Commerce
National Technical Information Service
NTIS

PB83-117366

EPA-600/2-82-070b
September 1982

ACID RAIN MITIGATION STUDY
Volume II. FGD Cost Estimates
(Appendices)

by

J.G. Ball and W.R. Menzies

Radian Corporation
8501 Mo-Pac Blvd
Austin, Texas 78766

EPA Contract No: 68-02-3171

Work Assignment 12

William Baasel and P.P. Turner
Technical Support Staff
Industrial Environmental Research Laboratory
U.S. Environmental Protection Agency
Research Triangle Park, NC 27711

Prepared for:

INDUSTRIAL ENVIRONMENTAL RESEARCH LABORATORY
OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
RESEARCH TRIANGLE PARK, NC 27711

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA 22161

TECHNICAL REPORT DATA

(Please read Instructions on the reverse before completing)

1. REPORT NO.
EPA-600/2-82-070b

2.

3. RECIPIENT'S ACCESSION NO.
PB83 117366

4. TITLE AND SUBTITLE
Acid Rain Mitigation Study: Volume II. FGD Cost Estimates (Appendices)

5. REPORT DATE
September 1982

6. PERFORMING ORGANIZATION CODE

7. AUTHOR(S)
J. G. Ball and W. R. Menzies

8. PERFORMING ORGANIZATION REPORT NO.
DCN 81-203-001-12-23

9. PERFORMING ORGANIZATION NAME AND ADDRESS
Radian Corporation
8501 Mo-Pac Boulevard
Austin, Texas 78766

10. PROGRAM ELEMENT NO.

11. CONTRACT/GRANT NO.
68-02-3171, Task 12

12. SPONSORING AGENCY NAME AND ADDRESS
EPA, Office of Research and Development
Industrial Environmental Research Laboratory
Research Triangle Park, NC 27711

13. TYPE OF REPORT AND PERIOD COVERED
Task Final; 2/80-2/81

14. SPONSORING AGENCY CODE
EPA/600/13

15. SUPPLEMENTARY NOTES IERL-RTP project officer William D. Baasel is no longer with EPA. For details, contact P. P. Turner, Mail Drop 62, 919/541-2826. Volume III is the industrial boiler technical report. Volume I is the estimates technical report.

16. ABSTRACT
The report gives results of work to provide a consistent set of capital investment and operating costs for flue gas desulfurization (FGD) systems retrofitted to existing industrial boilers. The investigation of wet limestone scrubbers and lime spray drying FGD systems included: (1) the apparent discontinuities in both FGD system capital investment and operating costs; (2) FGD retrofit factors applied to existing boilers based on published reports; and (3) differences between PEDCo Environmental, Inc. and TVA cost estimates for utility boiler FGD systems. These costing issues were examined on the bases of design scope, costing factors (for equipment installation, indirect investment, etc.), year of costs, inherent strengths and weaknesses, and published data of actual system costs. Recommendations are made for the cost bases to use in further acid rain studies.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS		b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group	
Pollution	Calcium Carbonates	Pollution Control	13B	07B
Flue Gases	Limestone	Stationary Sources	21B	08G
Desulfurization	Calcium Oxides	Lime	07A, 07D	
Cost Estimates	Rain	Acid Rain	05A, 04A	04B
Boilers	Acidity		13A	
Industrial Processes			13H	

18. DISTRIBUTION STATEMENT
Release to Public

19. SECURITY CLASS *(This Report)*
Unclassified

20. SECURITY CLASS *(This page)*
Unclassified

21. NO. OF PAGES
228

22. PRICE

EPA Form 2220-1 (9-73)

NOTICE

THIS DOCUMENT HAS BEEN REPRODUCED FROM THE BEST COPY FURNISHED US BY THE SPONSORING AGENCY. ALTHOUGH IT IS RECOGNIZED THAT CERTAIN PORTIONS ARE ILLEGIBLE, IT IS BEING RELEASED IN THE INTEREST OF MAKING AVAILABLE AS MUCH INFORMATION AS POSSIBLE.

1.6

NOTICE

This document has been reviewed in accordance with U.S. Environmental Protection Agency policy and approved for publication. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

ABSTRACT

The U.S. EPA has initiated a multiphased study of the acid rain problem. As part of Phase I, Radian Corporation investigated SO_2 emissions and controls in the industrial sector. The primary objective of this work was to provide a consistent set of capital investment and operating costs for flue gas desulfurization (FGD) systems applied to both industrial and electric utility boilers. Retrofit factors as well as the cost for FGD systems applied to new boilers were addressed. Wet limestone scrubbing and lime spray drying FGD systems were evaluated.

In conducting the work to provide a consistent set of capital investment and operating costs for FGD systems retrofitted to existing boilers, the following issues were investigated:

- The apparent discontinuities in both FGD system capital investment and operating costs as a function of boiler capacity in the region between industrial boilers and small utility boilers,
- FGD retrofit factors applied to existing boilers based on published reports, and
- The differences between PEDCo Environmental, Inc. and TVA cost estimates for utility boiler FGD systems.

These costing issues were examined on the bases of design scope, costing factors (for equipment installation, indirect investment, etc.), year of costs, inherent strengths and weaknesses, and published data of actual system costs. Recommendations are made for the cost bases to use in further acid rain studies.

TABLE OF CONTENTS

VOLUME I

Abstract. iii

List of Tables. ix

List of Figures xiii

1 INTRODUCTION AND SUMMARY 1-1

- 1.1 Introduction 1-1
- 1.2 Summary of Results 1-4
  - 1.2.1 Utility and Industrial Boiler FGD System Costs. 1-4
  - 1.2.2 FGD System Retrofit Factor Evaluation. . . . 1-15
  - 1.2.3 TVA & PEDCo Environmental, Inc. FGD System Cost Comparison 1-16

2 FLUE GAS DESULFURIZATION SYSTEM COST COMPARISONS FOR INDUSTRIAL AND UTILITY BOILERS 2-1

- 2.1 Wet Limestone FGD System Cost Estimates. 2-2
  - 2.1.1 Process Description. 2-2
  - 2.1.2 Limestone FGD System Capital Investment. . . 2-7
  - 2.1.2.1 Utility Boiler FGD System Capital Investment Estimates 2-9
  - 2.1.2.2 Industrial Boiler FGD System Capital Investment Estimates 2-13
  - 2.1.2.3 Comparison and Integration of Utility and Industrial Boiler FGD System Capital Investment Estimates 2-17
  - 2.1.2.4 Comparison of TVA Utility Boiler FGD System Capital Investment Estimates with Actual Installed FGD System Investment. 2-32
  - 2.1.2.5 Equipment on Actual Installed FGD Systems. . 2-36
  - 2.1.3 Limestone FGD System Annual Operating Cost Estimates 2-39
  - 2.1.3.1 Utility Boiler FGD System Annual Operating and Maintenance Cost Estimates 2-39
  - 2.1.3.2 Industrial Boiler FGD System Annual Operating and Maintenance Cost Estimates . . 2-44
  - 2.1.3.3 Comparison and Integration of Utility and Industrial Boiler FGD System Annual O&M Cost Estimates 2-48

Preceding page blank

TABLE OF CONTENTS (continued)

SECTION PAGE

2.1.4 Use of the Cost Estimate Results 2-58

2.2 Lime Spray Dryer FGD System Cost Estimates 2-60

2.2.1 Process Description. 2-60

2.2.2 Lime Spray Dryer FGD System Capital Investment 2-64

2.2.2.1 Utility Boiler Lime Spray Dryer Capital Investment Estimates 2-65

2.2.2.2 Industrial Boiler FGD System Capital Investment Estimates 2-68

2.2.2.3 Comparison and Integration of Utility and Boiler FGD System Capital Investment Estimates 2-70

2.2.3 Dry Scrubbing FGD System Annual O&M Cost Estimates 2-81

2.2.3.1 Utility Boiler FGD System Annual O&M Cost Estimates 2-81

2.2.3.2 Industrial Boiler FGD System Annual O&M Cost Estimates 2-85

2.2.3.3 Comparison and Integration of Utility and Industrial Boiler FGD System Annual Cost Estimates 2-88

2.2.4 Use of the Cost Estimate Results 2-98

References 2-100

3 FLUE GAS DESULFURIZATION SYSTEM RETROFIT COST ESTIMATES FOR UTILITY BOILERS 3-1

3.1 Review of Existing Studies 3-2

3.2 Current Studies. 3-14

3.3 Recommended Flue Gas Desulfurization Retrofit Factors. 3-16

3.3.1 Utility Boilers. 3-16

3.3.2 Industrial Boilers 3-18

References 3-19

TABLE OF CONTENTS (continued)

SECTION PAGE

4 COMPARISON OF TENNESSEE VALLEY AUTHORITY AND PEDCO ENVIRONMENTAL, INC. CAPITAL INVESTMENT AND ANNUAL COST ALGORITHMS FOR UTILITY BOILER FGD SYSTEMS. 4-1

4.1 Equipment Configuration Basis. 4-1

4.2 Economic Premises. 4-2

4.3 Capital Investment Algorithms. 4-2

4.4 Comparison of TVA and PEDCo Capital Investment . . . 4-2

4.5 Annual Operating Cost and Revenue Algorithms 4-8

4.6 Comparison of TVA and PEDCo Annual Operating Cost and Annual Revenue Requirement 4-11

4.7 Summary. 4-11

References 4-15

VOLUME II

APPENDICES

A Utility Boiler Limestone FGD System Premises A-1

B Industrial Boiler Limestone FGD System Premises. B-1

C Utility Boiler Limestone FGD System Premises on an "Industrial Basis" C-1

D Utility Boiler Lime Dry Scrubbing FGD System Premises. . . . D-1

E Industrial Boiler Lime Dry Scrubbing FGD System Premises . . E-1

F Description of TVA and PEDCo Environmental, Inc. Investment/Cost Components F-1

G Utility Boiler Lime FGD System Costs Comparison of TVA's Old and New Premises and PEDCo Environmental, Inc. Costs G-1

LIST OF TABLES

NUMBER		PAGE
1.2.1-1	Industrial Boiler Limestone FGD System Capital Investment. .	1-7
1.2.1-2	Industrial Boiler Limestone FGD System First Year Operating and Maintenance Costs.	1-8
1.2.1-3	Utility Boiler Limestone FGD System Capital Investment (1980$).	1-9
1.2.1-4	Utility Boiler Limestone FGD System First Year Operating and Maintenance Costs (1981$).	1-10
2.1.2-1	TVA Utility Boiler Wet Limestone FGD System Investment Bases.	2-10
2.1.2-2	TVA Utility Boiler Wet Limestone FGD System Design Scope . .	2-11
2.1.2-3	Utility Boiler Wet Limestone FGD System Capital Investment (1980$).	2-12
2.1.2-4	Industrial Boiler Wet Limestone FGD System Investment Bases.	2-14
2.1.2-5	Radian Industrial Boiler Wet Limestone FGD System Design Scope.	2-15
2.1.2-6	Radian Industrial Boiler Limestone FGD System Investment . .	2-16
2.1.2-7	Impact of Different Design Scope on TVA Utility Boiler FGD System Capital Investment.	2-20
2.1.2-8	Utility Boiler Limestone FGD System Investment on an Industrial Basis	2-21
2.1.2-9	Industrial Boiler Limestone FGD System Investment Using Industrial Installation Factors and Based on TVA Indirect Investment Algorithm	2-24
2.1.2-10	Limestone Wet Scrubbing FGD System Installation Factors. . .	2-26
2.1.2-11	Industrial Boiler Limestone FGD System Investment Using TVA Costing Algorithm for Both Equipment Installation and Indirect Investment.	2-27
2.1.2-12	Comparison of PEDCo Adjusted Capital Investment with TVA Estimates for Comparable Operating FGD Systems	2-33
2.1.2-13	Comparison of Final Adjusted PEDCo Capital Investment to TVA Estimates for Similar Operating FGD Systems.	2-34
2.1.2-14	Equipment Summary for 62 Operational Utility FGD Systems . .	2-37
2.1.3-1	TVA Utility Boiler Limestone FGD System Economic Premises and Assumptions.	2-40
2.1.3-2	Utility Boiler Limestone FGD System First Year Operating and Maintenance Costs.	2-41

Preceding page blank

LIST OF TABLES (continued)

NUMBER		PAGE
2.1.3-3	Radian Industrial Boiler Limestone FGD System Economic Assumptions.	2-45
2.1.3-4	Industrial Boiler Limestone FGD System First Year Operating and Maintenance Costs Using Radian Material and Operating Costs and Overhead Algorithm	2-46
2.1.3-5	Utility Boiler Limestone FGD System First Year Operating and Maintenance Costs on an Industrial Basis	2-49
2.1.3-6	Industrial Boiler Limestone FGD System First Year Operating and Maintenance Costs Using TVA Material and Operating Costs Plus Overhead Algorithm (Radian Investment Basis).	2-52
2.1.3-7	Industrial Boiler Limestone FGD System First Year Operating and Maintenance Costs Using TVA Material and Operating Costs Plus Overhead Algorithm (TVA Investment Basis, i.e. Installation Factors).	2-54
2.1.4-1	Summary of Limestone FGD System Cost Studies	2-59
2.2.2-1	Utility Boiler Lime Spray Dryer FGD System Capital Investment	2-67
2.2.2-2	Radian Industrial Boiler Lime Dry Scrubbing FGD System Capital Investment Estimates	2-69
2.2.2-3	Utility Boiler Lime Dry Scrubbing FGD System Capital Investment on an Industrial Basis.	2-72
2.2.2-4	Industrial Boiler Lime Dry Scrubbing FGD System Investment Calculated Using Industrial Installation Factors (Radian) and TVA Indirect Investment Algorithm.	2-75
2.2.2-5	Industrial Boiler Lime Dry Scrubbing FGD System Investment Using TVA Costing Algorithms for Both Equipment Installation and Indirect Investment.	2-77
2.2.3-1	TVA Utility Boiler Dry Scrubbing FGD System Economic Premises and Assumptions	2-82
2.2.3-2	Utility Boiler Lime Dry Scrubbing FGD System First-Year Operating and Maintenance Costs.	2-83
2.2.3-3	Industrial Boiler Lime Dry Scrubbing FGD System First-Year Operating and Maintenance Costs Using Radian Material and Operating Costs and Overhead Algorithm	2-86
2.2.3-4	Utility Boiler Lime Dry Scrubbing FGD System First-Year Operating and Maintenance Costs on an Industrial Basis . . .	2-89
2.2.3-5	Industrial Boiler Lime Dry Scrubbing FGD System First-Year Operating and Maintenance Costs Using TVA Material and Operating Costs Plus Overhead Algorithm (Radian Investment Basis)	2-91

LIST OF TABLES (continued)

NUMBER PAGE

2.2.3-6 Industrial Boiler Lime Dry Scrubbing FGD System First-Year Operating and Maintenance Costs Using TVA Material and Operating Costs Plus Overhead Algorithms (TVA Investment Basis, i.e., Installation Factors) 2-94

2.2.3-7 Summary of Lime Dry Scrubbing FGD Cost Studies 2-99

3.1-1 1972 M.W. Kellogg FGD System Retrofit Study. 3-3

3.1-2 Retrofit Factors From TVA Analysis (3.5% S Coal, 90% SO_2 Removal, On-site Solids Disposal). 3-5

3.1-3 PEDCo Power Plant FGD Capital Investment Retrofit Factors. . 3-7

3.2-1 Investment Retrofit Factor Evaluation. 3-15

3.3-1 Capital Investment Components. 3-17

4.1-1 Comparison of TVA and PEDCo Equipment Configuration and Operating Conditions 4-3

4.2-1 Comparison of TVA and PEDCo Economic Premises. 4-5

4.3-1 Comparison of TVA and PEDCo Capital Investment Algorithms. . 4-6

4.4-1 Design Bases for TVA and PEDCo Total Capital Investment Comparison 4-7

4.4-2 500 MWe Lime Slurry FGD System Capital Investment (3.5% S Coal, 90% SO_2 Removal, 1980$). 4-9

4.5-1 Comparison of TVA and PEDCo Annual Operating Cost and Revnue Algorithms. 4-10

4.6-1 500 MWe Lime Slurry FGD Annual Costs and Revenue (3.5% S Coal, 90% SO_2 Removal) 4-12

4.6-2 500 MWe Lime Slurry FGD Annual Costs on Same Unit Cost and Operating Basis (3.5% S Coal, 90% SO_2 Removal, 0.63 Capacity Factor). 4-13

LIST OF FIGURES

FIGURE PAGE

1.2.1-1 Capital Investment for Industrial and Utility Boiler Wet Limestone FGD Systems. 1-13

1.2.1-2 First Year O&M Costs for Industrial and Utility Wet Limestone FGD Systems. 1-14

2.1.1-1 Limestone FGD Process Flow Diagram 2-3

2.1.2-1 Comparison of Total Capital Investment for Small Industrial and Large Utility Boiler FGD Systems. 2-8

2.1.2-2 Difference in Capital Investment for Utility and Industrial Boiler Limestone FGD Systems. 2-18

2.1.2-3 Impact of Major Equipment Components on Costs of Large Utility Boiler FGD Systems 2-22

2.1.2-4 Impact of Using a Utility Indirect Investment Algorithm on Small Industrial Boiler FGD Systems 2-25

2.1.2-5 Impact of Using Large System Installation Factors and Utility Indirect Investment Algorithm on Small Industrial Boiler FGD Systems. 2-28

2.1.2-6 Comparison of All Cases for Limestone Wet Scrubbing FGD System Investment. 2-30

2.1.2-7 Equipment on 62 Operational Utility Boiler FGD Systems . . . 2-38

2.1.3-1 Utility Boiler Limestone FGD System First-Year Operating and Maintenance Costs. 2-42

2.1.3-2 Differences in First-Year Operating and Maintenance Costs for Utility and Industrial Boiler FGD Systems. 2-47

2.1.3-3 Impact of Putting Large Utility Boiler FGD Systems on an Industrial Basis 2-50

2.1.3-4 Impact of Putting Small Industrial Boiler FGD Systems on a Large Utility Boiler FGD System Basis 2-53

2.1.3-5 Impact of Putting Small Industrial Boiler FGD Systems on a Large Utility Boiler FGD System Basis, Including Investment 2-55

Preceding page blank

LIST OF FIGURES (continued)

FIGURE		PAGE
2.1.3-6	Comparison of All Cases for Wet Limestone Scrubbing FGD System First-Year Operating and Maintenance Costs.	2-56
2.2.1-1	Lime Spray Dryer Process Flow Diagram.	2-61
2.2.2-1	Differences in Capital Investment for Utility and Industrial Boiler FGD Systems.	2-71
2.2.2-2	Impact of Major Equipment Components on Costs of Large Utility Boiler FGD Systems	2-73
2.2.2-3	Impact of Using Utility Indirect Algorithm on Small Industrial Boiler FGD Systems.	2-76
2.2.2-4	Impact of Using Large System Installation Factors and a Utility Indirect Investment Algorithm on Small Industrial Boiler FGD Systems.	2-78
2.2.2-5	Comparison for All Low Sulfur Cases for Lime Dry Scrubbing FGD System Investment.	2-79
2.2.3-1	Utility Boiler FGD System First-Year Operating and Maintenance Costs.	2-84
2.2.3-2	Difference in First-Year Operating and Maintenance Costs for Utility and Industrial Boiler FGD Systems.	2-87
2.2.3-3	Impact of Putting Large Utility Boiler FGD Systems on an Industrial Basis.	2-90
2.2.3-4	Impact of Putting Small Industrial Boiler FGD Systems on a Large Utility System Basis	2-92
2.2.3-5	Impact of Putting Small Industrial Boiler FGD Systems on a Large Utility Boiler FGD System Basis, Including Investment	2-95
2.2.3-6	Comparison of all Low Sulfur Cases for Lime Dry Scrubbing FGD System First Year Operating and Maintenance Costs. . . .	2-96

VOLUME II

INTRODUCTION

There is a growing concern about the acidity of precipitation in the northeastern United States and Canada. Acidic precipitation is thought by many scientists to kill aquatic and plant life, damage crop-growing soil, and accelerate erosion and damage to buildings. Although the mechanisms producing acid rain are not clearly understood, sulfur dioxide (SO_2) and oxides of nitrogen (NO_x) are thought to be the precursors of the chemicals that cause acid rain. Large quantities of SO_2 and NO_x are produced by various combustion and non-combustion processes in both the utility and industrial sectors.[1] Reducing these SO_2 and NO_x emissions to the atmosphere should reduce the potential for acid rain.

Because this concern is increasing, the United States Environmental Protection Agency (EPA) initiated a multi-phased study of the acid rain problem. As one part of Phase I, Radian Corporation investigated SO_2 emissions and controls in the industrial sector, while Teknekron, Inc. made a similar study of the utility sector. The results of these studies would provide direction for additional phases. The objectives of the later phases are to investigate SO_2 sources in more detail than Phase I, to investigate NO_x sources, and to model source/receptor relationships.

In support of the Phase I efforts, Radian Corporation was asked to provide a consistent set of capital investment and operating costs for flue gas desulfurization (FGD) systems applied to both industrial and electric utility boilers. Since existing SO_2 sources are the primary targets for reducing the impacts of acid rain, retrofit factors as well as the cost for

FGD systems applied to new boilers were addressed. This report summarizes the results of that cost work.

The cost estimates used as the basis for this study are:

- Utility boiler FGD systems by TVA and PEDCo Environmental, Inc., and
- Industrial boiler FGD systems by Radian Corporation.

Wet limestone scrubbing and lime spray drying FGD systems were evaluated. The U.S. EPA has recognized that there appear to be discrepancies in these published cost estimates in two areas:

- Utility boiler limestone FGD system costs prepared by TVA and PEDCo Environmental, Inc., and
- FGD system costs in the capacity transition from industrial boilers to small utility boilers.

To achieve the primary objective of the study (provide a consistent set of capital investment and operating costs for FGD systems retrofitted to existing boilers), the following issues were investigated:

- The apparent discontinuities in both FGD system capital investment and operating costs as a function of boiler capacity in the region between industrial boilers and small utility boilers,
- FGD retrofit factors applied to existing boilers based on published reports, and
- The differences between PEDCo Environmental, Inc. and TVA cost estimates for utility boiler FGD systems.

The above costing issues are examined on the bases of design scope, costing factors*, year of costs, inherent strengths and weaknesses, and published data of actual system costs. Recommendations are made for the cost bases to use in further acid rain studies.

This report contains two volumes. Volume I is divided into four major sections. Section 1 contains an introduction and summary of results. The three issues described above are addressed in Sections 2, 3, and 4, respectively. Volume II, Appendices, contains the technical support for the study.

---

*For equipment installation, indirect investment, etc.

APPENDIX A

UTILITY BOILER LIMESTONE FGD SYSTEM PREMISES

MATERIAL BALANCES
EQUIPMENT LIST
CAPITAL INVESTMENT ESTIMATES
ANNUAL O&M COSTS
ANNUAL REVENUE REQUIREMENTS

APPENDIX A

TVA estimated the capital and operating costs for new limestone FGD systems applied to 100, 250, 500, and 1000 MW boilers. The computer output from TVA's cost estimating program for each case is presented in this Appendix. There are 16 pages of output for each case, and the following information is included:

1. Plant heat rate
2. Coal analysis
3. Flue gas characteristics
4. Limestone analysis
5. Complete FGD system design scope
6. Material and energy balances
7. FGD system operating conditions
8. Sludge pond design criteria
9. FGD system process stream characterization
10. Equipment list and costs
11. Equipment installation costs
12. Indirect investment costs
13. Annual O&M costs
14. Annual revenue requirements

In order to facilitate use of these outputs, the process capacity (100, 250, 500, or 1000 MW) is stamped on each page.

100 MW

```
EXAMPLE UTILITY, LIMESTONE, NEW ECONOMIC PREMISES                        CASE 005

                       *** INPUTS ***

BOILER CHARACTERISTICS
------ ---------------

MEGAWATTS =   100.     UTILITY BASIS - NEW POND BASIS

BOILER HEAT RATE =  9500. BTU/KWH

EXCESS AIR =  39. PERCENT, INCLUDING LEAKAGE

HOT GAS TEMPERATURE = 300. DEG F

COAL ANALYSIS, WT % AS FIRED :

 C       H      O      N      S      CL     ASH    H2O
66.70   3.80   5.60   1.30   3.36   0.10   15.10   4.00

SULFUR OVERHEAD =  92.0 PERCENT

ASH OVERHEAD =  80.0 PERCENT

HEATING VALUE OF COAL = 11700. BTU/LB

                              EFFICIENCY,    EMISSION,
FLYASH REMOVAL                    %          LBS/M BTU
------ -------               -----------    ---------

UPSTREAM OF SCRUBBER            99.7           0.03

WITHIN SCRUBBER                 50.0           0.02

COST OF UPSTREAM FLYASH REMOVAL EXCLUDED


ALKALI
------

LIMESTONE :

        CACO3        =  97.15 WT % DRY BASIS
        SOLUBLE MGO  =   0.0
        INERTS       =   2.85
        MOISTURE CONTENT =   5.00 LB H2O/100 LBS DRY LIMESTONE
        LIMESTONE HARDNESS WORK INDEX FACTOR = 10.00
        LIMESTONE DEGREE OF GRIND FACTOR =  1.35

FLY ASH :

        SOLUBLE CAO =   0.0  WT %
        SOLUBLE MGO =   0.0
        INERTS      = 100.00


RAW MATERIAL HANDLING AREA
--- -------- -------- ----

NUMBER OF REDUNDANT ALKALI PREPARATION UNITS =    0
```

Reproduced from
best available copy.

100 MW

```
SCRUBBER SYSTEM VARIABLES
-------- ------ ---------

NUMBER OF OPERATING SCRUBBING TRAINS =   1

NUMBER OF REDUNDANT SCRUBBING TRAINS =   1

NUMBER OF BEDS =   3

NUMBER OF GRIDS =   4

HEIGHT OF SPHERES PER BED =  5.0 INCHES

LIQUID-TO-GAS RATIO =  55. GAL/1000 ACF(SATD)

SCRUBBER GAS VELOCITY = 12.5 FT/SEC

INDUCED DRAFT SCRUBBER FAN OPTION

SCRUBBER PRESSURE = 14.7 PSIA

STOICHIOMETRY =  1.25 MOLE CACO3 ADDED AS LIMESTONE
                      PER MOLE (SO2+2HCL) ABSORBED

SO2 REMOVAL =  90. PERCENT

ENTRAINMENT LEVEL = 0.10 WT %

EHT RESIDENCE TIME =  12.0 MIN

SO2 OXIDIZED IN SYSTEM =  30.0 PERCENT

SOLIDS IN RECIRCULATED SLURRY =  15.0 WT %


SOLIDS DISPOSAL SYSTEM
------ -------- ------

COST OF LAND =  5000.00 DOLLARS/ACRE

SOLIDS IN SYSTEM SLUDGE DISCHARGE =  35.0 WT %

MAXIMUM POND AREA =  9999. ACRES

MAXIMUM EXCAVATION =  25.00 FT

DISTANCE TO POND =  5280. FT

POND LINED WITH 12.0 INCHES CLAY


STEAM REHEATER (IN-LINE)
----- -------- ---------

SATURATED STEAM TEMPERATURE =  470. DEG F

HEAT OF VAPORIZATION OF STEAM =  751. BTU/LB

OUTLET FLUE GAS TEMPERATURE = 175. DEG F

SUPERFICIAL GAS VELOCITY (FACE VELOCITY) =  25.0 FT/SEC
```

100 MW

```
EXAMPLE UTILITY, LIMESTONE, NEW ECONOMIC PREMISES                        CASE 005

                    *** OUTPUTS ***

HOT GAS TO SCRUBBER
--- --- -- --------

          MOLE PERCENT      LB-MOLE/HR       LB/HR

CO2         12.338          0.4509E+04       0.1985E+06
HCL          0.006          0.2270E+01       0.8351E+02
SO2          0.214          0.7829E+02       0.5015E+04
O2           5.560          0.2032E+04       0.6502E+05
N2          75.227          0.2749E+05       0.7704E+06
H2O          6.654          0.2432E+04       0.4381E+05

SO2 CONCENTRATION IN SCRUBBER INLET GAS = 2142. PPM
                                        = 3.28 LBS / MILLION BTU

FLYASH EMISSION =  0.03 LBS/MILLION BTU
                =  0.015 GRAINS/SCF (WET)  OR     29. LB/HR

          SOLUBLE CAO IN FLY ASH =     0. LB/HR
          SOLUBLE MGO IN FLY ASH =     0.

HOT GAS FLOW RATE =  .2309E+06 SCFM (60 DEG F, 14.7 PSIA)
                  =  .3374E+06 ACFM (300. DEG F, 14.7 PSIA)

CORRESPONDING COAL FIRING RATE =  .8120E+05 LB/HR

HOT GAS HUMIDITY =  0.042 LB H2O/LB DRY GAS

WET BULB TEMPERATURE = 124. DEG F


WET GAS FROM SCRUBBER
--- --- ---- --------

          MOLE PERCENT      LB-MOLE/HR       LB/HR

CO2         11.716          0.4582E+04       0.2017E+06
HCL          0.000          0.1145E+00       0.4175E+01
SO2          0.020          0.7829E+01       0.5015E+03
O2           5.169          0.2021E+04       0.6469E+05
N2          70.300          0.2749E+05       0.7704E+06
H2O         12.795          0.5004E+04       0.9015E+05

SO2 CONCENTRATION IN SCRUBBER OUTLET GAS =  200. PPM

FLYASH EMISSION =  0.02 LBS/MILLION BTU
                =  0.007 GRAINS/SCF (WET)  OR     15. LB/HR

TOTAL WATER PICKUP =   95.  GPH
           INCLUDING    2.3 GPM ENTRAINMENT

WET GAS FLOW RATE =  .2470E+06 SCFM (60 DEG F, 14.7 PSIA)
                  =  .2775E+06 ACFM (124. DEG F, 14.7 PSIA)

WET GAS SATURATION HUMIDITY =  0.087 LB H2O/LB DRY GAS
```

Reproduced from
best available copy.

100 MW

```
FLUE GAS TO STACK
---- --- -- -----

             MOLE PERCENT     LB-MOLE/HR      LB/HR

CO2              11.697       0.4582E+04      0.2017E+06
HCL               0.000       0.1145E+00      0.4175E+01
SO2               0.020       0.7829E+01      0.5015E+03
O2                5.160       0.2021E+04      0.6467E+05
N2               70.188       0.2749E+05      0.7704E+06
H2O              12.934       0.5067E+04      0.9120E+05

SPECIFIED  SO2 REMOVAL EFFICIENCY =  90.0 %

CALCULATED SO2 EMISSION =   0.53 POUNDS PER MILLION BTU

CALCULATED SO2 CONCENTRATION IN STACK GAS =     200. PPM

FLYASH EMISSION =  0.02 LBS/MILLION BTU
                =  0.007 GRAINS/SCF (WET)  OR     15. LB/HR

STACK GAS FLOW RATE =  .2474E+06 SCFM (60 DEG F, 14.7 PSIA)
                    =  .3022E+06 ACFM (175. DEG F, 14.7 PSIA)


STEAM REHEATER (IN-LINE)
----- -------- ---------

SUPERFICIAL GAS VELOCITY (FACE VELOCITY) =  25.0 FT/SEC

SQUARE PIPE PITCH = 2 TIMES ACTUAL PIPE O.D.

SATURATED STEAM TEMPERATURE =  470. DEG F

OUTLET FLUE GAS TEMPERATURE = 175. DEG F

REQUIRED HEAT INPUT TO REHEATER = 0.1316E+08 BTU/HR

STEAM CONSUMPTION = 0.1752E+05 LBS/HR


                                   HEAT TRANSFER
OUTSIDE PIPE    PRESSURE DROP,     COEFFICIENT,
DIAMETER, IN.   IN. H2O            BTU/HR FT2 DEG F
  1.00              0.65             0.2098E+02


                REHEATER           NUMBER OF
                OUTSIDE PIPE       PIPES PER      NUMBER OF
                AREA, SQ FT        BANK PER       BANKS (ROWS)
                PER TRAIN          TRAIN          PER TRAIN

INCONEL         0.1227E+04            81             4
CORTEN          0.7058E+03            81             2
TOTAL           0.1933E+04            81             6
```

100 MW

```
WATER BALANCE INPUTS
----- ------- ------

   RAINFALL(IN/YEAR)                     50.
   POND SEEPAGE(CM/SEC)*10**8            50.
   POND EVAPORATION(IN/YEAR)             32.


WATER BALANCE OUTPUTS
----- ------- -------

WATER AVAILABLE

   RAINFALL                             231. GPM                 115485. LB/HR
   ALKALI                                 1. GPM                    461. LB/HR
       TOTAL                            232. GPM                 115946. LB/HR


WATER REQUIRED

   HUMIDIFICATION                        93. GPM                  46339. LB/HR
   ENTRAINMENT                            2. GPM                   1126. LB/HR
   DISPOSAL WATER                        44. GPM                  22176. LB/HR
   HYDRATION WATER                        2. GPM                   1197. LB/HR
   CLARIFIER EVAPORATION                  0. GPM                      0. LB/HR
   POND EVAPORATION                     155. GPM                  77534. LB/HR
   SEEPAGE                               29. GPM                  14338. LB/HR

   TOTAL WATER REQUIRED                 326. GPM                 162709. LB/HR

NET WATER REQUIRED                       94. GPM                  46763. LB/HR
```

100 MW

```
SCRUBBER SYSTEM
-------- ------

TOTAL NUMBER OF SCRUBBING TRAINS (OPERATING+REDUNDANT) =  2

SO2 REMOVAL =  90.0 PERCENT

PARTICULATE REMOVAL IN SCRUBBER SYSTEM =  50.0 PERCENT

TCA PRESSURE DROP ACROSS  3 BEDS =  8.6 IN. H2O

TOTAL SYSTEM PRESSURE DROP = 14.7 IN. H2O

OVERRIDE TOTAL SYSTEM PRESSURE DROP = 20.0 IN. H2O

SPECIFIED   LIQUID-TO-GAS-RATIO    =  55. GAL/1000 ACF(SATD)

LIMESTONE ADDITION = 0.9214E+04 LB/HR DRY LIMESTONE

SPECIFIED  LIMESTONE STOICHIOMETRY  =  1.25 MOLE CACO3 ADDED AS LIMESTONE
                                           PER MOLE (SO2+2HCL) ABSORBED

SOLUBLE CAO FROM FLY ASH =  0.0  MOLE PER MOLE (SO2+2HCL) ABSORBED

TOTAL SOLUBLE MGO        =  0.0  MOLE PER MOLE (SO2+2HCL) ABSORBED

TOTAL STOICHIOMETRY      =  1.25 MOLE SOLUBLE (CA+MG)
                                 PER MOLE (SO2+2HCL) ABSORBED

SCRUBBER INLET LIQUOR PH =  5.66

MAKE UP WATER =   94. GPM

CROSS-SECTIONAL AREA PER SCRUBBER =   370. SQ FT

SYSTEM SLUDGE DISCHARGE
------ ------ ---------
                                                SOLID   LIQUID
                                                COMP,   COMP,
SPECIES           LB-MOLE/HR    LB/HR           WT %    PPM

CASO3 .1/2 H2O    0.4930E+02    0.6365E+04     52.92
CASO4 .2H2O       0.2088E+02    0.3594E+04     29.88
CACO3             0.1788E+02    0.1790E+04     14.88
INSOLUBLES        ----------    0.2773E+03      2.31
H2O               0.1231E+04    0.2218E+05
CA++              0.1384E+01    0.5548E+02              2484.
MG++              0.0           0.0                        0.
SO3--             0.3637E-01    0.2911E+01               130.
SO4--             0.2595E+00    0.2492E+02              1116.
CL-               0.2176E+01    0.7714E+02              3453.


TOTAL DISCHARGE FLOW RATE = 0.3436E+05 LB/HR
                          =    54.     GPM

TOTAL DISSOLVED SOLIDS IN DISCHARGE LIQUID =   7169. PPM

DISCHARGE LIQUID PH =  7.37
```

Reproduced from
best available copy.

100 MW

```
SCRUBBER SLURRY BLEED
-------- ------ -----

SPECIES           LB-MOLE/HR   LB/HR

CASO3 .1/2 H2O    0.4930E+02   0.6365E+04
CASO4 .2H2O       0.2088E+02   0.3594E+04
CACO3             0.1784E+02   0.1790E+04
INSOLUBLES        ----------   0.2773E+03
H2O               0.3756E+04   0.6766E+05
CA++              0.4223E+01   0.1693E+03
MG++              0.0          0.0
SO3--             0.1110E+00   0.8884E+01
SO4--             0.7917E+00   0.7605E+02
CL-               0.6639E+01   0.2354E+03
AD=               0.0          0.0

TOTAL FLOW RATE = 0.8018E+05 LB/HR
                =    146.    GPM


TOTAL SUPERNATE RETURN
----- --------- ------

SPECIES           LB-MOLE/HR   LB/HR

H2O               0.3826E+04   0.6893E+05
CA++              0.4303E+01   0.1724E+03
MG++              0.0          0.0
SO3--             0.1130E+00   0.9050E+01
SO4--             0.8065E+00   0.7747E+02
CL-               0.6764E+01   0.2398E+03
AD=               0.0          0.0

TOTAL FLOW RATE = 0.6943E+05 LB/HR
                =    139.    GPM


SUPERNATE TO WET BALL MILL
--------- -- --- ---- ----

SPECIES           LB-MOLE/HR   LB/HR

H2O               0.3385E+03   0.6099E+04
CA++              0.3807E+00   0.1526E+02
MG++              0.0          0.0
SO3--             0.1000E-01   0.8007E+00
SO4--             0.7135E-01   0.6854E+01
CL-               0.5984E+00   0.2121E+02
AD=               0.0          0.0

TOTAL FLOW RATE = 0.6143E+04 LB/HR
                =     12.    GPM
```

100 MW

```
LIMESTONE SLURRY FEED
--------- ------ ----

SPECIES            LB-MOLE/HR    LB/HR

CACO3              0.8943E+02    0.8952E+04
SOLUBLE MGO        0.0           0.0
INSOLUBLES         ----------    0.2626E+03
H2O                0.3385E 03    0.6099E+04
CA++               0.3807E+00    0.1526E+02
MG++               0.0           0.0
SO3--              0.1000E-01    0.6007E+00
SO4--              0.7135E-01    0.6854E+01
CL-                0.5984E+00    0.2121E+02
AD=                0.0           0.0

TOTAL FLOW RATE = 0.1536E+05 LB/HR
                =     19.     GPM

SUPERNATE RETURN TO SCRUBBER OR EHT
--------- ------ -- -------- -- ---

SPECIES            LB-MOLE/HR    LB/HR

H2O                0.3488E+04    0.6283E+05
CA++               0.3922E+01    0.1572E+03
MG++               0.0           0.0
SO3--              0.1030E+00    0.8249E+01
SO4--              0.7352E+00    0.7062E+02
CL-                0.6165E+01    0.2186E+03
AD=                0.0           0.0

TOTAL FLOW RATE = 0.6329E+05 LB/HR
                =    127.     GPM

RECYCLE SLURRY TO SCRUBBER
------- ------ -- --------

SPECIES            LB-MOLE/HR    LB/HR

CASO3 .1/2 H2O     0.5169E+04    0.6672E+06
CASO4 .2H2O        0.2189E+04    0.3767E+06
CACO3              0.1875E+04    0.1876E+06
INSOLUBLES         ----------    0.2907E+05
H2O                0.3937E+06    0.7093E+07
CA++               0.4427E+03    0.1774E+05
MG++               0.0           0.0
SO3--              0.1163E+02    0.9512E+03
SO4--              0.8298E+02    0.7971E+04
CL-                0.6959E+03    0.2467E+05
AD=                0.0           0.0

TOTAL FLOW RATE = 0.8404E+07 LB/HR
                =  15264.     GPM
```

100 MW

```
FLUE GAS COOLING SLURRY
---- --- ------- ------

SPECIES           LB-MOLE/HR   LB/HR

CASO3 .1/2 H2O    0.3759E+03   0.4852E+05
CASO4 .2H2O       0.1592E+03   0.2740E+05
CACO3             0.1363E+03   0.1365E+05
INSOLUBLES        ----------   0.2114E+04
H2O               0.2863E+05   0.5150E+06
CA++              0.3220E+02   0.1290E+04
MG++              0.0          0.0
SO3--             0.8459E+00   0.6772E+02
SO4--             0.6035E+01   0.5797E+03
CL-               0.5061E+02   0.1794E+04
AD=               0.0          0.0

TOTAL FLOW RATE = 0.6112E+06 LB/HR
                =   1110.    GPM
```

100 MW

```
                    POND DESIGN
                    ---- ------

   OPTIMIZED TO MINIMIZE TOTAL COST PLUS OVERHEAD


  POND DIMENSIONS
  ---- ----------

  DEPTH OF POND                     17.95 FT
  DEPTH OF EXCAVATION                4.69 FT
  LENGTH OF POND PERIMETER       7976.    FT
  LENGTH OF DIVIDER              1421.    FT
  LENGTH PERIMETER FENCE         8857.    FT

  AREA OF BOTTOM                  363.    THOUSAND YD2
  AREA OF INSIDE WALLS             69.    THOUSAND YD2
  AREA OF OUTSIDE WALLS            47.    THOUSAND YD2
  AREA OF RECLAIM STORAGE          17.    THOUSAND YD2
  AREA OF POND                    433.    THOUSAND YD2
  AREA OF POND SITE               592.    THOUSAND YD2
  AREA OF POND SITE               122.    ACRES

  VOLUME OF EXCAVATION            654.    THOUSAND YD3
  VOLUME OF RECLAIM STORAGE       263.    THOUSAND YD3
  VOLUME OF SLUDGE TO BE         2387.    THOUSAND YD3
  DISPOSED OVER LIFE OF PLANT    1480.    ACRE FT


  POND COSTS (THOUSANDS OF DOLLARS)
  ---- ----- ---------- -- --------

                                 LABOR    MATERIAL   TOTAL
                                 -----    --------   -----

  CLEARING LAND                   198.                198.
  EXCAVATION                     1624.               1624.
  DIKE CONSTRUCTION               845.                845.
  LINING( 12. IN. CLAY)           432.                432.
  SODDING DIKE WALLS               42.       28.       70.
  ROAD CONSTRUCTION                23.        7.       29.
  PERIMETER COSTS, FENCE+          44.       89.      133.
  RECLAMATION EXPENSE             327.                327.
  MONITOR WELLS                     4.        4.        8.
  ---------------------------------------------------------
  POND CONSTRUCTION              3540.      127.     3667.
  LAND COST                                           612.
  ---------------------------------------------------------
  POND SITE                                          4279.
  OVERHEAD                                           3132.
  ---------------------------------------------------------
  TOTAL                                              7411.
```

EXAMPLE UTILITY, LIMESTONE, NEW ECONOMIC PREMISES CASE 005

PARTICULATE REMOVAL INVESTMENT AND OPERATING COST

		PARTICULATE EMISSION REGULATION (LB ASH/MILLION BTU):	0.03
WPSUL CONTENT (%):	3.36	FLUE GAS TEMPERATURE (COLD) (F):	300.0
ASH CONTENT (%):	15.10	FLUE GAS TEMPERATURE (HOT) (F):	700.0
BTU RATING:	11700	COST OF ELECTRICITY ($/KWHR):	0.03
BOILER TYPE:	DRY PULVERIZED COAL	COST OF STEAM ($/THOUSAND LB):	2.00
NO. OF SCRUBBERS:	1	FIRST YEAR CAPITAL CHARGE FACTOR:	0.180
SCRUBBER VELOCITY (FT/M):	750.0	BAGHOUSE RATIO (OPER. SQ.FT./ACTUAL SQ.FT.):	0.80
PLANT SIZE (MW):	100	BAG COST ($/SQ.FT.):	0.70
OPERATING HRS/YR:	4731	BAG LIFE(YEARS):	3.00
PUMPING RATE (GAL/1000 ACF):	20.00	FLUE GAS REHEAT TEMPERATURE (F):	175.
SCA RATIO: (ACTUAL SQ.FT./CALC. SQ.FT.)	1.300	CHEMICAL ENGINEERING PLANT INDEX:	265.0

	ELECTROSTATIC PRECIPITATORS			
	COLD	HOT	BAGHOUSE FABRIC FILTERS	SCRUBBERS
REQUIRED REMOVAL EFFICIENCY (%):	99.70	99.70	99.70	99.70
DRIFT VELOCITY (FT/M):	27.19	20.00		
SPECIFIC COLLECTION AREA (SQ.FT./ACFM):	277.74	377.59		
COLLECTION AREA (SQ.FT.):	93715.4	194462.1	173226.8	
TOTAL CORONA POWER (KW):	132.7	202.6		
AUXILIARY POWER (KW):	68.4	153.6	168.9	
FAN POWER (KW):	52.8	80.6	264.0	3208.0
PUMP POWER (KW):				653.6
TOTAL POWER (KW):	253.9	436.8	432.9	3861.5
OPERATING AIR/CLOTH RATIO:			2.4	
INSTALLED AIR/CLOTH RATIO:			1.9	
REQUIRED PRESSURE DROP (INCHES):	1.0	1.0	5.0	60.8
DIAMETER (FEET):				27
REQUIRED REHEAT (BTU/HR):				12853818.0
STEAM SUPPLY/YR (THOUSAND LB):				67568.2
INSTALLED COST (1979 DOLLARS):	$ 1582453	$ 2921883	$ 4277191	$ 5917050
FIRST YEAR CAPITALIZED COST:	$ 285369	$ 526913	$ 771320	$ 1067041
ANNUAL POWER COST:	$ 34835	$ 59927	$ 59391	$ 529800
ANNUAL OPERATING AND MAINTENANCE COST (1979 DOLLARS):	$ 46137	$ 69233	$ 49387	$ 310499
REPLACEMENT COST (1979 DOLLARS):			$ 53026	
ANNUAL REHEAT COST:				$ 135136
TOTAL ANNUAL COST:	$ 366341	$ 656073	$ 933124	$ 2042476
ANNUALIZED COST OF POWER(MILLS/KWHR):	0.77	1.39	1.97	4.32

RAW MATERIAL HANDLING AND PREPARATION

ITEM	DESCRIPTION	NO.	MATERIAL	LABOR
MOBILE EQUIPMENT	BUCKET TRACTOR	1	65176.	0.
RECLAIM HOPPER	7FT WIDE, 4.25FT HT, 2FT WIDE BOTTOM, CS	1	1035.	675.
RECLAIM VIBRATING FEEDER	3.5HP	1	4687.	432.
RECLAIM BELT CONVEYOR	100FT, 2HP	1	19618.	1188.
RECLAIM INCLINE BELT CONVEYOR	193FT, 40HP	1	51661.	3024.
RECLAIM PIT DUST COLLECTOR	POLYPROPYLENE BAG TYPE	1	6648.	2160.
RECLAIM PIT SUMP PUMP	60GPM, 70FT HEAD, 5HP	1	2071.	648.
RECLAIM BUCKET ELEVATOR	90FT HIGH, 75HP	1	49591.	5509.
FEED BIN	13FT DIA, 21FT STRAIGHT SIDE HT, COVERED, CS	1	12370.	6643.
BIN WEIGH FEEDER	14FT PULLEY CENTERS, 2HP	1	14169.	648.
GYRATORY CRUSHERS	75HP	1	84904.	1782.
BALL MILL DUST COLLECTORS	POLYPROPYLENE BAG TYPE 2200 CFM, 7.5HP	1	6648.	2160.
BALL MILL	4.6TPH, 100.HP	1	137073.	16396.
MILLS PRODUCT TANK	5500 GAL 10FT DIA, 10FT HT, FLAKEGLASS LINED CS	1	3924.	3024.
MILLS PRODUCT TANK AGITATOR	10HP	1	6539.	1512.
MILLS PRODUCT TANK SLURRY PUMP	19.GPM, 60FT HEAD, 1.HP, 1 OPERATING AND 1 SPARES	2	4530.	1512.
SLURRY FEED TANK	10237.GAL, 12.0FT DIA, 12.0FT HT, FLAKEGLASS-LINED CS	1	5370.	4287.
SLURRY FEED TANK AGITATOR	15.HP	1	10825.	658.
SLURRY FEED TANK PUMPS	19.GPM, 60 FT HEAD, 1.HP, 1 OPERATING AND 2 SPARE	3	6795.	2268.
			----------	----------
TOTAL EQUIPMENT COST			493634.	54726.

100 MW

SCRUBBING

INCLUDING 1 OPERATING AND 1 SPARE SCRUBBING TRAINS

ITEM	DESCRIPTION	NO.	MATERIAL	LABOR
I.D. FANS	20.0IN H2O, WITH 1268. HP MOTOR AND DRIVE	2	1552064.	21697.
SHELL			454959.	
RUBBER LINING			442549.	
MIST ELIMINATOR			85091.	
SLURRY HEADER AND NOZZLES			104675.	
GRIDS			182020.	
SPHERES			251071.	
TOTAL TCA SCRUBBER COSTS		2	1520363.	110173.
REHEATERS		2	735393.	45007.
SOOTBLOWERS		24	101143.	60486.
EFFLUENT HOLD TANK	201489.GAL, 32.5FT DIA, 32.5FT HT, FLAKEGLASS-LINED CS	2	89695.	70031.
EFFLUENT HOLD TANK AGITATOR	57.HP	2	118956.	18862.
COOLING SPRAY PUMPS	1110.GPM 100FT HEAD, 51.HP, 1 OPERATING AND 3 SPARE	4	31939.	9700.
ABSORBER RECYCLE PUMPS	7632.GPM, 100FT HEAD, 354.HP, 2 OPERATING AND 4 SPARE	6	439298.	33790.
MAKEUP WATER PUMPS	555.GPM, 200.FT HEAD, 47.HP, 1 OPERATING AND 1 SPARE	2	10905.	1189.
			---------	---------
TOTAL EQUIPMENT COST			4599752.	370936.

WASTE DISPOSAL

ITEM	DESCRIPTION	NO.	MATERIAL	LABOR
ABSORBER BLEED RECEIVING TANK	30320.GAL, 16.2FT DIA, 32.5FT HT, FLAKGLASS-LINED CS	1	17856.	14266.
ABSORBER BLEED TANK AGITATOR	33.HP	1	20219.	1603.
POND FEED SLURRY PUMPS	146.GPM, 130.FT HEAD 4.HP, 2 OPERATING AND 2 SPARE	4	13702.	3993.
POND SUPERNATE PUMPS	139.GPM, 192.FT HEAD, 11.HP, 1 OPERATING AND 1 SPARE	2	8181.	892.
			----------	----------
TOTAL EQUIPMENT COST			59958.	20754.

100 MW

LIMESTONE SLURRY PROCESS -- BASIS: 100 MW UNIT, 1981 STARTUP

PROJECTED CAPITAL INVESTMENT REQUIREMENTS - EXAMPLE UTILITY, LIMESTONE, NEW ECONOMIC PREMISES CASE 005

	INVESTMENT, THOUSANDS OF 1980 DOLLARS				DISTRIBUTION
	RAW MATERIAL HANDLING AND PREPARATION	SCRUBBING	WASTE DISPOSAL	TOTAL	PERCENT OF DIRECT INVESTMENT
EQUIPMENT					
MATERIAL	494.	4600.	60.	5153.	31.9
LABOR	55.	371.	21.	446.	2.8
PIPING					
MATERIAL	215.	1188.	482.	1886.	11.7
LABOR	86.	252.	186.	524.	3.2
DUCTWORK					
MATERIAL	0.	746.	0.	746.	4.6
LABOR	0.	588.	0.	588.	3.6
FOUNDATIONS					
MATERIAL	110.	42.	17.	169.	1.0
LABOR	301.	89.	34.	423.	2.6
POND CONSTRUCTION	0.	0.	3667.	3667.	22.7
STRUCTURAL					
MATERIAL	37.	105.	1.	142.	0.9
LABOR	35.	176.	1.	213.	1.3
ELECTRICAL					
MATERIAL	94.	223.	122.	439.	2.7
LABOR	176.	444.	257.	876.	5.4
INSTRUMENTATION					
MATERIAL	49.	257.	9.	315.	2.0
LABOR	7.	41.	8.	57.	0.4
BUILDINGS					
MATERIAL	14.	0.	0.	14.	0.1
LABOR	15.	0.	0.	15.	0.1
SERVICES AND MISCELLANEOUS	51.	276.	147.	474.	2.9
SUBTOTAL DIRECT INVESTMENT	1738.	9399.	5013.	16149.	100.0
ENGINEERING DESIGN AND SUPERVISION	156.	846.	451.	1453.	9.0
CONSTRUCTION EXPENSES	278.	1504.	802.	2584.	16.0
CONTRACTOR FEES	87.	470.	251.	807.	5.0
CONTINGENCY	452.	2444.	1303.	4199.	26.0
SUBTOTAL FIXED INVESTMENT	2711.	14663.	7820.	25192.	156.0
ALLOWANCE FOR STARTUP AND MODIFICATIONS	209.	1128.	602.	1938.	12.0
INTEREST DURING CONSTRUCTION	407.	2199.	1173.	3779.	23.4
SUBTOTAL CAPITAL INVESTMENT	3327.	17990.	9595.	30909.	191.4
LAND	9.	1.	624.	634.	3.9
WORKING CAPITAL	88.	477.	254.	820.	5.1
TOTAL CAPITAL INVESTMENT	3424.	18468.	10473.	32363.	200.4

100 MW

```
LIMESTONE SLURRY PROCESS -- BASIS:  100 MW UNIT, 1981 STARTUP
PROJECTED REVENUE REQUIREMENTS - EXAMPLE UTILITY, LIMESTONE, NEW ECONOMIC PREMISES                    CASE 005

                              DISPLAY SHEET FOR YEAR=    1
                            ANNUAL OPERATION KW-HR/KW =  4731  -  0.54 cap factor

                  6.01 TONS PER HOUR                          DRY              SLUDGE
                       TOTAL CAPITAL INVESTMENT       31393000                   TOTAL
                                                                                ANNUAL
                                          ANNUAL QUANTITY       UNIT COST,$     COST,$
                                          ---------------       -----------     ------
   DIRECT COSTS
   ------------
     RAW MATERIAL
     ------------
       LIMESTONE                           21.8 K TONS          8.00/TON        174400
                                                                             ----------
          SUBTOTAL RAW MATERIAL                                                 174400

     CONVERSION COSTS
     ----------------
       OPERATING LABOR AND
         SUPERVISION                      13760.0 MAN-HR      12.50/MAN-HR      172000
       UTILITIES
         STEAM                            82870.0 K LB         2.00/K LB        165700
         PROCESS WATER                    26560.0 K GAL        0.12/K GAL         3200
         ELECTRICITY                    9088790.0 KWH          0.029/KWH        263600
       MAINTENANCE
         LABOR AND MATERIAL                                                    1108600
       ANALYSES                            3060.0 HR          17.00/HR           52000
       Sludge Disposal                                                       ----------
          SUBTOTAL CONVERSION COSTS                                            1765100

          SUBTOTAL DIRECT COSTS                                                1939500

   INDIRECT COSTS
   --------------
     OVERHEADS
       PLANT AND ADMINISTRATIVE (  60.0% OF CONVERSION COSTS LESS UTILITIES)    799560
                                                                             ----------
     FIRST YEAR OPERATING AND MAINTENANCE COSTS                                2739100
     LEVELIZED CAPITAL CHARGES(  14.7% OF TOTAL CAPITAL INVESTMENT)            4757360
                                                                             ----------
        FIRST YEAR ANNUAL REVENUE REQUIREMENTS                                 7496460

        EQUIVALENT FIRST YEAR UNIT REVENUE REQUIREMENTS, MILLS/KWH               15.86
-------------------------------------------------------------------------------------------------
     LEVELIZED OPERATING AND MAINTENANCE ( 1.886 TIMES FIRST YEAR OPER. & MAIN.)  5165900
     LEVELIZED CAPITAL CHARGES( 11.64% OF TOTAL CAPITAL INVESTMENT)            4757360
                                                                             ----------
        LEVELIZED ANNUAL REVENUE REQUIREMENTS                                  9923260

        EQUIVALENT LEVELIZED UNIT REVENUE REQUIREMENTS, MILLS/KWH                20.97
-------------------------------------------------------------------------------------------------
     HEAT RATE   9500. BTU/KWH    -     HEAT VALUE OF COAL      11700 BTU/LB    -   COAL RATE    192100 TONS/YR
```

Reproduced from
best available copy.

250 MW

```
EXAMPLE UTILITY, LIMESTONE, NEW ECONOMIC PREMISES                      CASE 006

                      *** INPUTS ***

BOILER CHARACTERISTICS
------ ---------------

MEGAWATTS =   250.        UTILITY BASIS - NEW POND BASIS

BOILER HEAT RATE =  9500. BTU/KWH

EXCESS AIR =  39. PERCENT, INCLUDING LEAKAGE

HOT GAS TEMPERATURE = 300. DEG F

COAL ANALYSIS, WT % AS FIRED :

 C       H       O       N       S       CL     ASH     H2O
66.70   3.80    5.60    1.30    3.36    0.10   15.10    4.00

SULFUR OVERHEAD =  92.0 PERCENT

ASH OVERHEAD =  80.0 PERCENT

HEATING VALUE OF COAL = 11700. BTU/LB

                          EFFICIENCY,    EMISSION,
FLYASH REMOVAL                 %         LBS/M BTU
------ -------            -----------    ---------

UPSTREAM OF SCRUBBER         99.7           0.03

WITHIN SCRUBBER              50.0           0.02

COST OF UPSTREAM FLYASH REMOVAL EXCLUDED


ALKALI
------

LIMESTONE :

        CACO3        =  97.15 WT % DRY BASIS
        SOLUBLE MGO =    0.0
        INERTS       =    2.65
        MOISTURE CONTENT =    5.00 LB H2O/100 LBS DRY LIMESTONE
        LIMESTONE HARDNESS WORK INDEX FACTOR = 10.00
        LIMESTONE DEGREE OF GRIND FACTOR =  1.35

FLY ASH :

        SOLUBLE CAO =    0.0  WT %
        SOLUBLE MGO =    0.0
        INERTS       = 100.00


RAW MATERIAL HANDLING AREA
--- -------- -------- ----

NUMBER OF REDUNDANT ALKALI PREPARATION UNITS =     0
```

250 MW

```
SCRUBBER SYSTEM VARIABLES
-------- ------ ---------

NUMBER OF OPERATING SCRUBBING TRAINS =   2

NUMBER OF REDUNDANT SCRUBBING TRAINS =   1

NUMBER OF BEDS =   3

NUMBER OF GRIDS =   4

HEIGHT OF SPHERES PER BED =  5.0 INCHES

LIQUID-TO-GAS RATIO =  55. GAL/1000 ACF(SATD)

SCRUBBER GAS VELOCITY = 12.5 FT/SEC

INDUCED DRAFT SCRUBBER FAN OPTION

SCRUBBER PRESSURE = 14.7 PSIA

STOICHIOMETRY =  1.25 MOLE CACO3 ADDED AS LIMESTONE
                      PER MOLE (SO2+2HCL) ABSORBED

SO2 REMOVAL =  90. PERCENT

ENTRAINMENT LEVEL = 0.10 WT %

EMT RESIDENCE TIME =  12.0 MIN

SO2 OXIDIZED IN SYSTEM =  30.0 PERCENT

SOLIDS IN RECIRCULATED SLURRY =  15.0 WT %


SOLIDS DISPOSAL SYSTEM
------ -------- ------

COST OF LAND =  5000.00 DOLLARS/ACRE

SOLIDS IN SYSTEM SLUDGE DISCHARGE =  35.0 WT %

MAXIMUM POND AREA =  9999. ACRES

MAXIMUM EXCAVATION =  25.00 FT

DISTANCE TO POND =  5280. FT

POND LINED WITH 12.0 INCHES CLAY


STEAM REHEATER (IN-LINE)
----- -------- ---------

SATURATED STEAM TEMPERATURE =  470. DEG F

HEAT OF VAPORIZATION OF STEAM =  751. BTU/LB

OUTLET FLUE GAS TEMPERATURE = 175. DEG F

SUPERFICIAL GAS VELOCITY (FACE VELOCITY) =  25.0 FT/SEC
```

250 MW

```
EXAMPLE UTILITY, LIMESTONE, NEW ECONOMIC PREMISES                    CASE 006

                         *** OUTPUTS ***

HOT GAS TO SCRUBBER
--- --- -- --------

          MOLE PERCENT      LB-MOLE/HR      LB/HR

CO2          12.338        0.1127E+05      0.4961E+06
HCL           0.006        0.5726E+01      0.2088E+03
SO2           0.214        0.1957E+03      0.1254E+05
O2            5.560        0.5080E+04      0.1626E+06
N2           75.227        0.6874E+05      0.1926E+07
H2O           6.654        0.6080E+04      0.1095E+06

SO2 CONCENTRATION IN SCRUBBER INLET GAS = 2142. PPM
                                        = 5.28 LBS / MILLION BTU

FLYASH EMISSION =  0.03 LBS/MILLION BTU
                =  0.015 GRAINS/SCF (WET)  OR     74. LB/HR

        SOLUBLE CAO IN FLY ASH =      0. LB/HR
        SOLUBLE MGO IN FLY ASH =      0.

HOT GAS FLOW RATE =  .5772E+06 SCFM (60 DEG F, 14.7 PSIA)
                  =  .8435E+06 ACFM (300. DEG F, 14.7 PSIA)

CORRESPONDING COAL FIRING RATE =  .2030E+06 LB/HR

HOT GAS HUMIDITY =  0.042 LB H2O/LB DRY GAS

WET BULB TEMPERATURE = 124. DEG F


WET GAS FROM SCRUBBER
--- --- ---- --------

          MOLE PERCENT      LB-MOLE/HR      LB/HR

CO2          11.716        0.1146E+05      0.5042E+06
HCL           0.000        0.2863E+00      0.1044E+02
SO2           0.020        0.1957E+02      0.1254E+04
O2            5.169        0.5054E+04      0.1617E+06
N2           70.300        0.6874E+05      0.1926E+07
H2O          12.795        0.1251E+05      0.2254E+06

SO2 CONCENTRATION IN SCRUBBER OUTLET GAS =  200. PPM

FLYASH EMISSION =  0.02 LBS/MILLION BTU
                =  0.007 GRAINS/SCF (WET)  OR     37. LB/HR

TOTAL WATER PICKUP =  237.  GPM
          INCLUDING    5.6 GPM ENTRAINMENT

WET GAS FLOW RATE =  .6176E+06 SCFM (60 DEG F, 14.7 PSIA)
                  =  .6938E+06 ACFM (124. DEG F, 14.7 PSIA)

WET GAS SATURATION HUMIDITY =  0.087 LB H2O/LB DRY GAS
```

Reproduced from
best available copy.

250 MW

FLUE GAS TO STACK

```
           MOLE PERCENT     LB-MOLE/HR     LB/HR

  CO2         11.697        0.1146E+05     0.5042E+06
  HCL          0.000        0.2863E+00     0.1044E+02
  SO2          0.020        0.1957E+02     0.1254E+04
  O2           5.160        0.5054E+04     0.1617E+06
  N2          70.188        0.6874E+05     0.1926E+07
  H2O         12.934        0.1267E+05     0.2282E+06

  SPECIFIED  SO2 REMOVAL EFFICIFNCY =  90.0 %

  CALCULATED SO2 EMISSION =   0.53 POUNDS PER MILLION BTU

  CALCULATED SO2 CONCENTRATION IN STACK GAS =     200. PPM

  FLYASH EMISSION =  0.02 LBS/MILLION BTU
                  =  0.007 GRAINS/SCF (WET)  OR     37. LB/HR

  STACK GAS FLOW RATE =  .6186E+06 SCFM (60 DEG F, 14.7 PSIA)
                      =  .7554E+06 ACFM (175. DEG F, 14.7 PSIA)

  STEAM REHEATER (IN-LINE)
  ----- -------- ---------

  SUPERFICIAL GAS VELOCITY (FACE VELOCITY) =  25.0 FT/SEC

  SQUARE PIPE PITCH = 2 TIMES ACTUAL PIPE O.D.

  SATURATED STEAM TEMPERATURE =  470. DEG F

  OUTLET FLUE GAS TEMPERATURE = 175. DEG F

  REQUIRED HEAT INPUT TO REHEATER = 0.3289E+08 BTU/HR

  STEAM CONSUMPTION = 0.4379E+05 LBS/HR

                                    HEAT TRANSFER
  OUTSIDE PIPE    PRESSURE DROP,    COEFFICIENT,
  DIAMETER, IN.   IN. H2O           BTU/HR FT2 DEG F
   1.00              0.65             0.2098E+02

                  REHEATER         NUMBER OF
                  OUTSIDE PIPE     PIPES PER      NUMBER OF
                  AREA, SQ FT      BANK PER       BANKS (ROWS)
                  PER TRAIN        TRAIN          PER TRAIN

  INCONEL         0.1533E+04          91             4
  CORTEN          0.8823E+03          91             2
  TOTAL           0.2416E+04          91             6
```

250 MW

```
WATER BALANCE INPUTS
----- ------- ------

  RAINFALL(IN/YEAR)                      50.
  POND SEEPAGE(CM/SEC)*10**8             50.
  POND EVAPORATION(IN/YEAR)              32.


WATER BALANCE OUTPUTS
----- ------- -------

WATER AVAILABLE

  RAINFALL                              496. GPM              248145. LB/HR
  ALKALI                                  2. GPM                1152. LB/HR
      TOTAL                             499. GPM              249297. LB/HR


WATER REQUIRED

  HUMIDIFICATION                        232. GPM              115848. LB/HR
  ENTRAINMENT                             6. GPM                2815. LB/HR
  DISPOSAL WATER                        111. GPM               55439. LB/HR
  HYDRATION WATER                         6. GPM                2992. LB/HR
  CLARIFIER EVAPORATION                   0. GPM                   0. LB/HR
  POND EVAPORATION                      336. GPM              167870. LB/HR
  SEEPAGE                                62. GPM               30809. LB/HR

  TOTAL WATER REQUIRED                  752. GPM              375773. LB/HR

NET WATER REQUIRED                      253. GPM              126476. LB/HR
```

250 MW

```
SCRUBBER SYSTEM
------- ------

TOTAL NUMBER OF SCRUBBING TRAINS (OPERATING+REDUNDANT) =  3

SO2 REMOVAL =  90.0 PERCENT

PARTICULATE REMOVAL IN SCRUBBER SYSTEM =  50.0 PERCENT

TCA PRESSURE DROP ACROSS  3 BEDS =  8.6 IN. H2O

TOTAL SYSTEM PRESSURE DROP = 14.7 IN. H2O

OVERRIDE TOTAL SYSTEM PRESSURE DROP = 20.0 IN. H2O

SPECIFIED   LIQUID-TO-GAS-RATIO     =  55. GAL/1000 ACF(SATD)

LIMESTONE ADDITION = 0.2304E+05 LB/HR DRY LIMESTONE

SPECIFIED  LIMESTONE STOICHIOMETRY  =  1.25 MOLE CACO3 ADDED AS LIMESTONE
                                           PER MOLE (SO2+2HCL) ABSORBED

SOLUBLE CAO FROM FLY ASH =  0.0  MOLE PER MOLE (SO2+2HCL) ABSORBED

TOTAL SOLUBLE MGO        =  0.0  MOLE PER MOLE (SO2+2HCL) ABSORBED

TOTAL STOICHIOMETRY      =  1.25 MOLE SOLUBLE (CA+MG)
                                 PER MOLE (SO2+2HCL) ABSORBED

SCRUBBER INLET LIQUOR PH =  5.66

MAKE UP WATER =  253. GPM

CROSS-SECTIONAL AREA PER SCRUBBER =   463. SQ FT


SYSTEM SLUDGE DISCHARGE
------ ------ ---------                        SOLID   LIQUID
                                               COMP,   COMP,
SPECIES           LB-MOLE/HR    LB/HR          WT %    PPM

CASO3 .1/2 H2O    0.1233E+03    0.1591E+05    52.92
CASO4 .2H2O       0.5221E+02    0.8986E+04    29.88
CACO3             0.4471E+02    0.4476E+04    14.88
INSOLUBLES        ----------    0.6933E+03     2.31
H2O               0.3077E+04    0.5544E+05
CA++              0.3460E+01    0.1387E+03              2489.
MG++              0.0           0.0                        0.
SO3--             0.9091E-01    0.7278E+01               130.
SO4--             0.6486E+00    0.6231E+02              1116.
CL-               0.5440E+01    0.1929E+03              3453.


TOTAL DISCHARGE FLOW RATE = 0.8391E+05 LB/HR
                          =   135.     GPM

TOTAL DISSOLVED SOLIDS IN DISCHARGE LIQUID =   7169. PPM

DISCHARGE LIQUID PH =  7.57
```

250 MW

```
SCRUBBER SLURRY BLEED
------- ------ -----

SPECIES           LB-MOLE/HR    LB/HR

CASO3 .1/2 H2O    0.1233E+03    0.1591E+05
CASO4 .2H2O       0.5221E+02    0.8989E+04
CACO3             0.4471E+02    0.4476E+04
INSOLUBLES        ----------    0.6932E+03
H2O               0.9389E+04    0.1692E+06
CA++              0.1056E+02    0.4232E+03
MG++              0.0           0.0
SO3--             0.2774E+00    0.2221E+02
SO4--             0.1979E+01    0.1901E+03
CL-               0.1660E+02    0.5884E+03
AD=               0.0           0.0

TOTAL FLOW RATE = 0.2004E+06 LB/HR
                =    364.     GPM


TOTAL SUPERNATE RETURN
----- --------- ------

SPECIES           LB-MOLE/HR    LB/HR

H2O               0.9038E+04    0.1628E+06
CA++              0.1016E+02    0.4074E+03
MG++              0.0           0.0
SO3--             0.2670E+00    0.2138E+02
SO4--             0.1905E+01    0.1830E+03
CL-               0.1598E+02    0.5664E+03
AD=               0.0           0.0

TOTAL FLOW RATE = 0.1640E+06 LB/HR
                =    328.     GPM


SUPERNATE TO WET BALL MILL
--------- -- --- ---- ----

SPECIES           LB-MOLE/HR    LB/HR

H2O               0.7912E+03    0.1425E+05
CA++              0.8897E+00    0.3566E+02
MG++              0.0           0.0
SO3--             0.2339E-01    0.1873E+01
SO4--             0.1664E+00    0.1602E+02
CL-               0.1399E+01    0.4958E+02
AD=               0.0           0.0

TOTAL FLOW RATE = 0.1436E+05 LB/HR
                =     29.     GPM
```

250 MW

```
LIMESTONE SLURRY FEED
--------- ------ ----

SPECIES             LB-MOLE/HR    LB/HR

CACO3               0.2236E+03    0.2236E+05
SOLUBLE MGO         0.0           0.0
INSOLUBLES          ----------    0.6565E+03
H2O                 0.8463E+03    0.1525E+05
CA++                0.8897E+00    0.3566E+02
MG++                0.0           0.0
SO3--               0.2338E-01    0.1871E+01
SO4--               0.1668E+00    0.1602E+02
CL-                 0.1399E+01    0.4958E+02
AD=                 0.0           0.0

TOTAL FLOW RATE = 0.3839E+05 LB/HR
                =     48.     GPM

SUPERNATE RETURN TO SCRUBBER OR EHT
--------- ------ -- -------- -- ---

SPECIES             LB-MOLE/HR    LB/HR

H2O                 0.8247E+04    0.1486E+06
CA++                0.9274E+01    0.3717E+03
MG++                0.0           0.0
SO3--               0.2437E+00    0.1951E+02
SO4--               0.1738E+01    0.1670E+03
CL-                 0.1458E+02    0.5168E+03
AD=                 0.0           0.0

TOTAL FLOW RATE = 0.1497E+06 LB/HR
                =    299.     GPM

RECYCLE SLURRY TO SCRUBBER
------- ------ -- --------

SPECIES             LB-MOLE/HR    LB/HR

CASO3 .1/2 H2O      0.1292E+05    0.1668E+07
CASO4 .2H2O         0.5473E+04    0.9419E+06
CACO3               0.4687E+04    0.4691E+06
INSOLUBLES          ----------    0.7267E+05
H2O                 0.9842E+06    0.1773E+08
CA++                0.1107E+04    0.4436E+05
MG++                0.0           0.0
SO3--               0.2908E+02    0.2328E+04
SO4--               0.2075E+03    0.1993E+05
CL-                 0.1740E+04    0.6166E+05
AD=                 0.0           0.0

TOTAL FLOW RATE = 0.2101E+08 LB/HR
                =  38161.     GPM
```

250 MW

```
FLUE GAS COOLING SLURRY
---- --- ------- ------

SPECIES            LB-MOLE/HR    LB/HR

CASO3 .1/2 H2O     0.9396E+03    0.1213E+06
CASO4 .2H2O        0.3980E+03    0.6850E+05
CACO3              0.3408E+03    0.3412E+05
INSOLUBLES         ----------    0.5245E+04
H2O                0.7158E+05    0.1290E+07
CA++               0.8049E+02    0.3226E+04
MG++               0.0           0.0
SO3--              0.2115E+01    0.1693E+03
SO4--              0.1509E+02    0.1449E+04
CL-                0.1265E+03    0.4486E+04
AD-                0.0           0.0

TOTAL FLOW RATE = 0.1528E+07 LB/HR
                =   2775.      GPM
```

250 MW

```
                    POND DESIGN
                    ---- ------

   OPTIMIZED TO MINIMIZE TOTAL COST PLUS OVERHEAD


  POND DIMENSIONS
  ---- ----------

  DEPTH OF POND                     20.44 FT
  DEPTH OF EXCAVATION                4.26 FT
  LENGTH OF POND PERIMETER       11654.   FT
  LENGTH OF DIVIDER               2106.   FT
  LENGTH PERIMETER FENCE         12612.   FT

  AREA OF BOTTOM                   818.   THOUSAND YD2
  AREA OF INSIDE WALLS             113.   THOUSAND YD2
  AREA OF OUTSIDE WALLS             81.   THOUSAND YD2
  AREA OF RECLAIM STORAGE           80.   THOUSAND YD2
  AREA OF POND                     930.   THOUSAND YD2
  AREA OF POND SITE               1185.   THOUSAND YD2
  AREA OF POND SITE                245.   ACRES

  VOLUME OF EXCAVATION            1295.   THOUSAND YD3
  VOLUME OF RECLAIM STORAGE        538.   THOUSAND YD3
  VOLUME OF SLUDGE TO BE          5967.   THOUSAND YD3
  DISPOSED OVER LIFE OF PLANT     3699.   ACRE FT


  POND COSTS (THOUSANDS OF DOLLARS)
  ---- ----- ---------- -- --------

                                 LABOR    MATERIAL   TOTAL
                                 -----    --------   -----

  CLEARING LAND                   397.                397.
  EXCAVATION                     3218.               3218.
  DIKE CONSTRUCTION              1635.               1635.
  LINING( 12. IN. CLAY)           931.                931.
  SODDING DIKE WALLS               71.        46.     118.
  ROAD CONSTRUCTION                33.        10.      43.
  PERIMETER COSTS, FENCE+          63.       126.     189.
  RECLAIMATION EXPENSE            654.                654.
  MONITOR WELLS                     4.         4.       8.
  ------------------------------------------------------------
  POND CONSTRUCTION              7005.       187.    7192.
  LAND COST                                          1224.
  ------------------------------------------------------------
  POND SITE                                          8415.
  OVERHEAD                                           6142.
  ------------------------------------------------------------
  TOTAL                                             14557.
```

250 MW

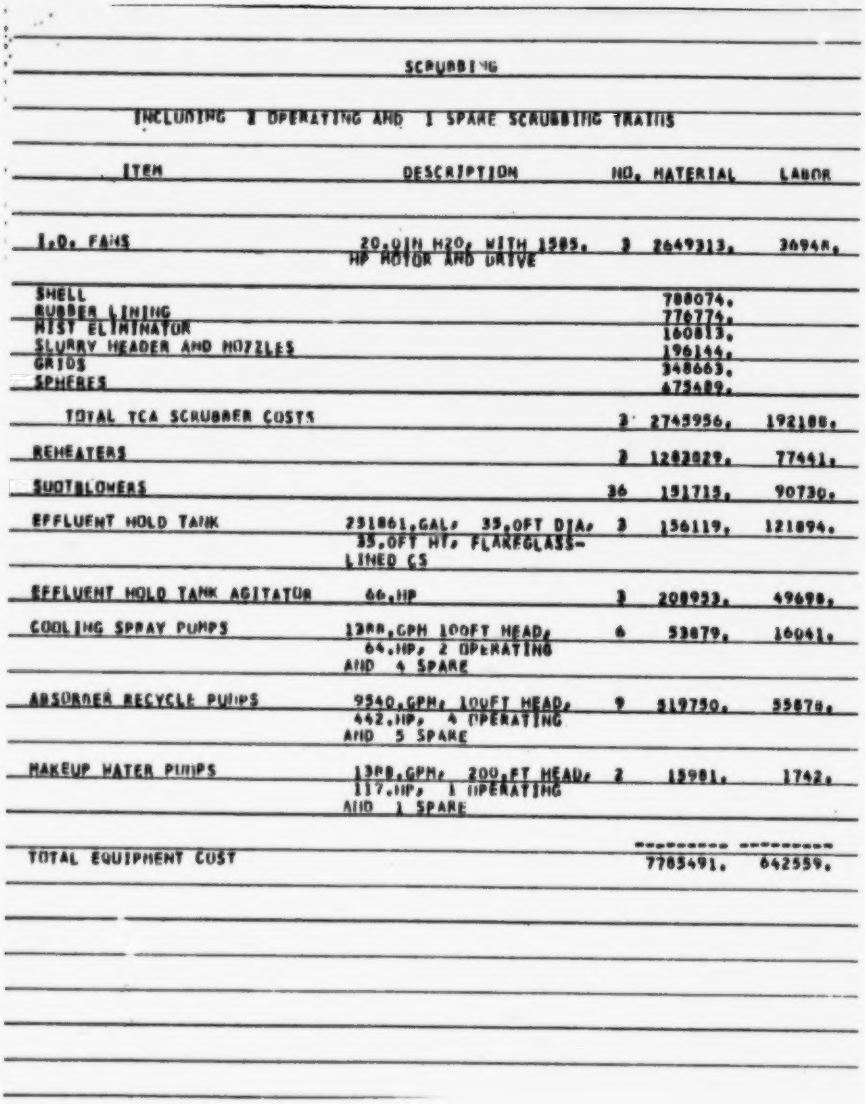
```
           EXAMPLE UTILITY, LIMESTONE, NEW ECONOMIC PREMISES                  CASE 006

                             PARTICULATE REMOVAL INVESTMENT AND OPERATING COST
                                                       PARTICULATE EMISSION REGULATION (LB ASH/MILLION BTU):   0.03
  WPSUL CONTENT (%):            3.36                   FLUE GAS TEMPERATURE (COLD) (F):                      300.0
  ASH CONTENT (%):             15.10                   FLUE GAS TEMPERATURE (HOT) (F):                       700.0
  BTU RATING:                  11700                   COST OF ELECTRICITY ($/KWHR):                           0.03
  BOILER TYPE:                 DRY PULVERIZED COAL     COST OF STEAM ($/THOUSAND LB):                          2.00
  NO. OF SCRUBBERS:                2                   FIRST YEAR CAPITAL CHARGE FACTOR:                       0.180
  SCRUBBER VELOCITY (FT/M):    750.0                   BAGHOUSE RATIO (OPER. SQ.FT./ACTUAL SQ.FT.):            0.80
  PLANT SIZE (MW):               250                   BAG COST ($/SQ.FT.):                                    0.70
  OPERATING HRS/YR:             4731                   BAG LIFE(YEARS):                                      3.00
  PUMPING RATE (GAL/1000 ACF): 20.00                   FLUE GAS REHEAT TEMPERATURE (F):                      175.
  SCA RATIO:                   1.300                   CHEMICAL ENGINEERING PLANT INDEX:                     265.0
    (ACTUAL SQ.FT./CALC. SQ.FT.)



                                        ELECTROSTATIC PRECIPITATORS

                                          COLD          HOT          BAGHOUSE FABRIC FILTERS     SCRUBBERS

  REQUIRED REMOVAL EFFICIENCY (%):        99.70         99.70               99.70                99.70
  DRIFT VELOCITY (FT/M):                  27.19         20.00
  SPECIFIC COLLECTION AREA (SQ.FT./ACFM): 277.74        377.59
  COLLECTION AREA (SQ.FT.):            234288.6      486155.2            433067.2
  TOTAL CORONA POWER (KW):               331.8         506.4
  AUXILIARY POWER (KW):                  188.9         424.3               309.8
  FAN POWER (KW):                        132.0         201.5               660.0               8020.0
  PUMP POWER (KW):                                                                             1633.9
  TOTAL POWER (KW):                      652.7        1132.2               969.8               9653.9
  OPERATING AIR/CLOTH RATIO:                                                 2.4
  INSTALLED AIR/CLOTH RATIO:                                                 1.9
  REQUIRED PRESSURE DROP (INCHES):         1.0           1.0                 5.0                 60.8
  DIAMETER (FFET):                                                                                30
  REQUIRED REHEAT (BTU/HR):                                                                32134544.0
  STEAM SUPPLY/YR (THOUSAND LB):                                                             168920.6
  INSTALLED COST (1979 DOLLARS):     $ 3556565     $ 6585005          $ 9162336            $ 12732165
  FIRST YEAR CAPITALIZED COST:       $  641367     $ 1187495          $ 1652274            $  2296033
  ANNUAL POWER COST:                 $   89547     $  155342          $  133059            $  1324499
  ANNUAL OPERATING AND
   MAINTENANCE COST (1979 DOLLARS):  $   76790     $  115231          $   57651            $   668123
  REPLACEMENT COST (1979 DOLLARS):                                    $  132564
  ANNUAL REHEAT COST:                                                                      $   337841



  TOTAL ANNUAL COST:                 $  807704     $ 1458068          $ 1975548            $  4626496
  ANNUALIZED COST OF POWER(MILLS/KWHR):   0.68          1.23                1.67                 3.91
```

250 MW

RAW MATERIAL HANDLING AND PREPARATION

ITEM	DESCRIPTION	NO.	MATERIAL	LABOR
MOBILE EQUIPMENT	BUCKET TRACTOR	1	65176.	0.
RECLAIM HOPPER	7FT WIDE, 4.25FT HT, 2FT WIDE BOTTOM, CS	1	1035.	675.
RECLAIM VIBRATING FEEDER	3.5HP	1	4687.	432.
RECLAIM BELT CONVEYOR	100FT, 2HP	1	19618.	1188.
RECLAIM INCLINE BELT CONVEYOR	193FT, 40HP	1	51661.	3024.
RECLAIM PIT DUST COLLECTOR	POLYPROPYLENE BAG TYPE	1	6648.	2160.
RECLAIM PIT SUMP PUMP	60GPM, 70FT HEAD, 5HP	1	2071.	648.
RECLAIM BUCKET ELEVATOR	90FT HIGH, 75HP	1	49591.	5509.
FEED BIN	13FT DIA, 21FT STRAIGHT SIDE HT, COVERED, CS	1	12370.	6648.
BIN WEIGH FEEDER	14FT PULLEY CENTERS, 2HP	1	14169.	646.
GYRATORY CRUSHERS	75HP	1	84904.	1782.
BALL MILL DUST COLLECTORS	POLYPROPYLENE BAG TYPE 2200 CFM, 7.5HP	1	6648.	2160.
BALL MILL	11.5TPH, 155.HP	1	162639.	18645.
MILLS PRODUCT TANK	5500 GAL 10FT DIA, 10FT HT, FLAKEGLASS LINED CS	1	3924.	3024.
MILLS PRODUCT TANK AGITATOR	10HP	1	6539.	1512.
MILLS PRODUCT TANK SLURRY PUMP	48.GPM, 60FT HEAD, 2.HP, 1 OPERATING AND 1 SPARES	2	4830.	1512.
SLURRY FEED TANK	25592.GAL, 16.3FT DIA, 16.3FT HT, FLAKEGLASS-LINED CS	1	9691.	7896.
SLURRY FEED TANK AGITATOR	25.HP	1	20701.	1641.
SLURRY FEED TANK PUMPS	24.GPM, 60 FT HEAD, 1.HP, 2 OPERATING AND 3 SPARE	5	11486.	3780.
TOTAL EQUIPMENT COST			538589.	62881.

250 MW



SCRUBBING

INCLUDING 2 OPERATING AND 1 SPARE SCRUBBING TRAINS

ITEM	DESCRIPTION	NO.	MATERIAL	LABOR
I.D. FANS	20.0IN H2O, WITH 1585. HP MOTOR AND DRIVE	3	2649313.	36948.
SHELL			788074.	
RUBBER LINING			776774.	
MIST ELIMINATOR			160813.	
SLURRY HEADER AND NOZZLES			196144.	
GRIDS			348663.	
SPHERES			475489.	
TOTAL TCA SCRUBBER COSTS		3	2745956.	192188.
REHEATERS		3	1283029.	77441.
SOOTBLOWERS		36	151715.	90730.
EFFLUENT HOLD TANK	231861.GAL, 35.0FT DIA, 35.0FT HT, FLAKEGLASS-LINED CS	3	156119.	121894.
EFFLUENT HOLD TANK AGITATOR	66.HP	3	208953.	49698.
COOLING SPRAY PUMPS	1388.GPM 100FT HEAD, 64.HP, 2 OPERATING AND 4 SPARE	6	53879.	16041.
ABSORBER RECYCLE PUMPS	9540.GPM, 100FT HEAD, 442.HP, 4 OPERATING AND 5 SPARE	9	519750.	55878.
MAKEUP WATER PUMPS	1388.GPM, 200.FT HEAD, 117.HP, 1 OPERATING AND 1 SPARE	2	15981.	1742.
TOTAL EQUIPMENT COST			7785491.	642559.

250 MW

```
                                  WASTE DISPOSAL

        ITEM                          DESCRIPTION          NO. MATERIAL    LABOR

 ABSORBER BLEED RECEIVING        62898.GAL, 17.5FT DIA,    1     20720.     16554.
 TANK                            35.0FT HT, FLAKGLASS-
                                LINED CS

 ABSORBER BLEED TANK AGITATOR     38.HP                    1     23676.      1677.

 POND FEED SLURRY PUMPS           364.GPM,  130.FT HEAD    2      9108.      2980.
                                  22.HP,  1 OPERATING
                                AND  1 SPARE

 POND SUPERNATE PUMPS             328.GPM,  192.FT HEAD,   2      9394.      1024.
                                  26.HP,  1 OPERATING
                                AND  1 SPARE
                                                              --------- ---------
 TOTAL EQUIPMENT COST                                            62898.     22435.
```

250 MW

LIMESTONE SLURRY PROCESS -- BASIS: 250 MW UNIT, 1981 STARTUP

PROJECTED CAPITAL INVESTMENT REQUIREMENTS - EXAMPLE UTILITY, LIMESTONE, NEW ECONOMIC PREMISES CASE 006

	INVESTMENT, THOUSANDS OF 1980 DOLLARS				DISTRIBUTION
	RAW MATERIAL HANDLING AND PREPARATION	SCRUBBING	WASTE DISPOSAL	TOTAL	PERCENT OF DIRECT INVESTMENT
EQUIPMENT					
MATERIAL	539.	7785.	63.	8387.	31.3
LABOR	63.	643.	22.	728.	2.7
PIPING					
MATERIAL	240.	2032.	669.	2941.	11.0
LABOR	109.	401.	237.	748.	2.8
DUCTWORK					
MATERIAL	0.	1351.	0.	1351.	5.0
LABOR	0.	1079.	0.	1079.	4.0
FOUNDATIONS					
MATERIAL	113.	77.	17.	207.	0.8
LABOR	306.	162.	34.	502.	1.9
POND CONSTRUCTION	0.	0.	7192.	7192.	26.8
STRUCTURAL					
MATERIAL	37.	172.	1.	211.	0.8
LABOR	35.	290.	2.	328.	1.2
ELECTRICAL					
MATERIAL	98.	424.	124.	645.	2.4
LABOR	187.	808.	261.	1256.	4.7
INSTRUMENTATION					
MATERIAL	57.	386.	9.	453.	1.7
LABOR	8.	62.	8.	79.	0.3
BUILDINGS					
MATERIAL	18.	0.	0.	18.	0.1
LABOR	19.	0.	0.	19.	0.1
SERVICES AND MISCELLANEOUS	46.	398.	220.	664.	2.5
SUBTOTAL DIRECT INVESTMENT	1875.	16070.	8859.	26805.	100.0
ENGINEERING DESIGN AND SUPERVISION	169.	1446.	797.	2412.	9.0
CONSTRUCTION EXPENSES	300.	2571.	1418.	4289.	16.0
CONTRACTOR FEES	94.	804.	443.	1340.	5.0
CONTINGENCY	488.	4178.	2303.	6969.	26.0
SUBTOTAL FIXED INVESTMENT	2926.	25069.	13820.	41816.	156.0
ALLOWANCE FOR STARTUP AND MODIFICATIONS	225.	1928.	1063.	3217.	12.0
INTEREST DURING CONSTRUCTION	439.	3760.	2073.	6272.	23.4
SUBTOTAL CAPITAL INVESTMENT	3590.	30757.	16956.	51305.	191.4
LAND	9.	2.	1236.	1247.	4.7
WORKING CAPITAL	97.	832.	459.	1388.	5.2
TOTAL CAPITAL INVESTMENT	3696.	31591.	18651.	53932.	201.2

250 MW

```
LIMESTONE SLURRY PROCESS -- BASIS:  250 MW UNIT, 1981 STARTUP

PROJECTED REVENUE REQUIREMENTS - EXAMPLE UTILITY, LIMESTONE, NEW ECONOMIC PREMISES                    CASE 006

                                        DISPLAY SHEET FOR YEAR=    1
                                      ANNUAL OPERATION KW-HR/KW =  4731

                        15.03 TONS PER HOUR                              DRY              SLUDGE
                              TOTAL CAPITAL INVESTMENT       52332000                          TOTAL
                                                                                               ANNUAL
                                             ANNUAL QUANTITY        UNIT COST,$               COST,$
                                             ---------------        -----------               ------
    DIRECT COSTS
    ------------
      RAW MATERIAL
      ------------
        LIMESTONE                                   54.5 K TONS       8.00/TON                 435900
                                                                                           ----------
          SUBTOTAL RAW MATERIAL                                                                435900

      CONVERSION COSTS
      ----------------
        OPERATING LABOR AND
          SUPERVISION                           20810.0 MAN-HR      12.50/MAN-HR               260100
        UTILITIES
          STEAM                                207180.0 K LB         2.00/K LB                 414400
          PROCESS WATER                         71830.0 K GAL        0.12/K GAL                  8600
          ELECTRICITY                        20837870.0 KWH          0.029/KWH                 604300
        MAINTENANCE
          LABOR AND MATERIAL                                                                  1784800
        ANALYSES                                 3060.0 HR          17.00/HR                    52000
                                                                                           ----------
          SUBTOTAL CONVERSION COSTS                                                           3124200

          SUBTOTAL DIRECT COSTS                                                               3560100

    INDIRECT COSTS
    --------------
      OVERHEADS
        PLANT AND ADMINISTRATIVE (  60.0% OF CONVERSION COSTS LESS UTILITIES)                 1258100
                                                                                           ----------
      FIRST YEAR OPERATING AND MAINTENANCE COSTS                                              4818200
      LEVELIZED CAPITAL CHARGES(  14.7% OF TOTAL CAPITAL INVESTMENT)                          7928000
                                                                                           ----------
          FIRST YEAR ANNUAL REVENUE REQUIREMENTS                                             12746200

          EQUIVALENT FIRST YEAR UNIT REVENUE REQUIREMENTS, MILLS/KWH                            10.77
-----------------------------------------------------------------------------------------------------------------------
      LEVELIZED OPERATING AND MAINTENANCE ( 1.886 TIMES FIRST YEAR OPER. & MAIN.)             9087100
      LEVELIZED CAPITAL CHARGES( 11.64% OF TOTAL CAPITAL INVESTMENT)
                                                                                              7928000
                                                                                           ----------
          LEVELIZED ANNUAL REVENUE REQUIREMENTS                                              17015100

          EQUIVALENT LEVELIZED UNIT REVENUE REQUIREMENTS, MILLS/KWH                             14.83
-----------------------------------------------------------------------------------------------------------------------
      HEAT RATE   9500. BTU/KWH    -    HEAT VALUE OF COAL    11700 BTU/LB    -    COAL RATE    480200 TONS/YR
```

500 MW

```
    EXAMPLE UTILITY, LIMESTONE, NEW ECONOMIC PREMISES                         CASE 007

                        *** INPUTS ***

    BOILER CHARACTERISTICS
    ------ ---------------

    MEGAWATTS =   500.    UTILITY BASIS - NEW POND BASIS

    BOILER HEAT RATE =  9500. BTU/KWH

    EXCESS AIR =  39. PERCENT, INCLUDING LEAKAGE

    HOT GAS TEMPERATURE = 300. DEG F

    COAL ANALYSIS, WT % AS FIRED :

     C       H       O       N       S       CL     ASH     H2O
    66.70   3.80    5.60    1.30    3.36    0.10   15.10    4.00

    SULFUR OVERHEAD =  92.0 PERCENT

    ASH OVERHEAD =  80.0 PERCENT

    HEATING VALUE OF COAL = 11700. BTU/LB

                                     EFFICIENCY,     EMISSION,
    FLYASH REMOVAL                       %           LBS/M BTU
    ------ -------                  -----------     ---------

    UPSTREAM OF SCRUBBER               99.7            0.03

    WITHIN SCRUBBER                    50.0            0.02

    COST OF UPSTREAM FLYASH REMOVAL EXCLUDED

    ALKALI
    ------

    LIMESTONE :

            CACO3         =  97.15 WT % DRY BASIS
            SOLUBLE MGO =    0.0
            INERTS        =   2.85
            MOISTURE CONTENT =   5.00 LB H2O/100 LBS DRY LIMESTONE
            LIMESTONE HARDNESS WORK INDEX FACTOR = 10.00
            LIMESTONE DEGREE OF GRIND FACTOR =  1.35

    FLY ASH :

            SOLUBLE CAO =   0.0  WT %
            SOLUBLE MGO =   0.0
            INERTS       = 100.00

    RAW MATERIAL HANDLING AREA
    --- -------- -------- ----

    NUMBER OF REDUNDANT ALKALI PREPARATION UNITS =    0
```

500 MW

```
SCRUBBER SYSTEM VARIABLES
-------- ------ ---------

NUMBER OF OPERATING SCRUBBING TRAINS =   4
NUMBER OF REDUNDANT SCRUBBING TRAINS =   1
NUMBER OF BEDS =   3
NUMBER OF GRIDS =   4
HEIGHT OF SPHERES PER BED =  5.0 INCHES
LIQUID-TO-GAS RATIO =  55. GAL/1000 ACF(SATD)
SCRUBBER GAS VELOCITY = 12.5 FT/SEC
INDUCED DRAFT SCRUBBER FAN OPTION
SCRUBBER PRESSURE = 14.7 PSIA
STOICHIOMETRY =  1.25 MOLE CACO3 ADDED AS LIMESTONE
                      PER MOLE (SO2+2HCL) ABSORBED
SO2 REMOVAL =  90. PERCENT
ENTRAINMENT LEVEL = 0.10 WT %
EHT RESIDENCE TIME =  12.0 MIN
SO2 OXIDIZED IN SYSTEM =  30.0 PERCENT
SOLIDS IN RECIRCULATED SLURRY =  15.0 WT %

SOLIDS DISPOSAL SYSTEM
------ -------- ------

COST OF LAND =  5000.00 DOLLARS/ACRE
SOLIDS IN SYSTEM SLUDGE DISCHARGE =  35.0 WT %
MAXIMUM POND AREA =  9999. ACRES
MAXIMUM EXCAVATION =  25.00 FT
DISTANCE TO POND =  5280. FT
POND LINED WITH 12.0 INCHES CLAY


STEAM REHEATER (IN-LINE)
----- -------- ---------

SATURATED STEAM TEMPERATURE =  470. DEG F
HEAT OF VAPORIZATION OF STEAM =  751. BTU/LB
OUTLET FLUE GAS TEMPERATURE = 175. DEG F
SUPERFICIAL GAS VELOCITY (FACE VELOCITY) =  25.0 FT/SEC
```

Reproduced from
best available copy.

500 MW

```
EXAMPLE UTILITY, LIMESTONE, NEW ECONOMIC PREMISES                          CASE 007

                         *** OUTPUTS ***

HOT GAS TO SCRUBBER
--- --- -- --------

          MOLE PERCENT      LB-MOLE/HR      LB/HR

CO2         12.338          0.2255E+05      0.9923E+06
HCL          0.006          0.1145E+02      0.4175E+03
SO2          0.214          0.3914E+03      0.2508E+05
O2           5.560          0.1016E+05      0.3251E+06
N2          75.227          0.1375E+06      0.3852E+07
H2O          6.654          0.1216E+05      0.2191E+06

SO2 CONCENTRATION IN SCRUBBER INLET GAS = 2142. PPM
                                        = 5.28 LBS / MILLION BTU

FLYASH EMISSION =  0.03 LBS/MILLION BTU
                =  0.015 GRAINS/SCF (WET)  OR    147. LB/HR

        SOLUBLE CAO IN FLY ASH =      0. LB/HR
        SOLUBLE MGO IN FLY ASH =      0.

HOT GAS FLOW RATE =  .1154E+07 SCFM (60 DEG F, 14.7 PSIA)
                  =  .1687E+07 ACFM (300. DEG F, 14.7 PSIA)

CORRESPONDING COAL FIRING RATE =  .4060E+06 LB/HR

HOT GAS HUMIDITY =  0.042 LB H2O/LB DRY GAS

WET BULB TEMPERATURE = 124. DEG F


WET GAS FROM SCRUBBER
--- --- ---- --------

          MOLE PERCENT      LB-MOLE/HR      LB/HR

CO2         11.716          0.2291E+05      0.1008E+07
HCL          0.000          0.5726E+00      0.2088E+02
SO2          0.020          0.3914E+02      0.2508E+04
O2           5.169          0.1011E+05      0.3234E+06
N2          70.300          0.1375E+06      0.3852E+07
H2O         12.795          0.2502E+05      0.4508E+06

SO2 CONCENTRATION IN SCRUBBER OUTLET GAS =  200. PPM

FLYASH EMISSION =  0.02 LBS/MILLION BTU
                =  0.007 GRAINS/SCF (WET)  OR     74. LB/HR

TOTAL WATER PICKUP =  475.  GPM
          INCLUDING   11.3 GPM ENTRAINMENT

WET GAS FLOW RATE =  .1235E+07 SCFM (60 DEG F, 14.7 PSIA)
                  =  .1388E+07 ACFM (124. DEG F, 14.7 PSIA)

WET GAS SATURATION HUMIDITY =  0.087 LB H2O/LB DRY GAS
```

500 MW

FLUE GAS TO STACK

```
          MOLE PERCENT      LB-MOLE/HR      LB/HR

CO2          11.697         0.2271E+05     0.1000E+07
HCL           0.000         0.5726E+00     0.2088E+02
SO2           0.020         0.3914E+02     0.2508E+04
O2            5.160         0.1011E+05     0.3234E+06
N2           70.109         0.1375E+06     0.3852E+07
H2O          12.934         0.2533E+05     0.4564E+06

SPECIFIED  SO2 REMOVAL EFFICIENCY =  90.0 %

CALCULATED SO2 EMISSION =   0.53 POUNDS PER MILLION BTU

CALCULATED SO2 CONCENTRATION IN STACK GAS =     200. PPM


FLYASH EMISSION =  0.02 LBS/MILLION BTU
                =  0.007 GRAINS/SCF (WET)  OR     74. LB/HR

STACK GAS FLOW RATE =  .1237E+07 SCFM (60 DEG F, 14.7 PSIA)
                    =  .1511E+07 ACFM (175. DEG F, 14.7 PSIA)


STEAM REHEATER (IN-LINE)
----- -------- ---------

SUPERFICIAL GAS VELOCITY (FACE VELOCITY) =  25.0 FT/SEC

SQUARE PIPE PITCH = 2 TIMES ACTUAL PIPE O.D.

SATURATED STEAM TEMPERATURE =  470. DEG F

OUTLET FLUE GAS TEMPERATURE = 175. DEG F

REQUIRED HEAT INPUT TO REHEATER = 0.6578E+08 BTU/HR

STEAM CONSUMPTION = 0.8750E+05 LBS/HR


                                  HEAT TRANSFER
OUTSIDE PIPE   PRESSURE DROP,    COEFFICIENT,
DIAMETER, IN.  IN. H2O           BTU/HR FT2 DEG F
  1.00             0.65             0.2098E+02


                 REHEATER        NUMBER OF
                 OUTSIDE PIPE    PIPES PER     NUMBER OF
                 AREA, SQ FT     BANK PER      BANKS (ROWS)
                 PER TRAIN       TRAIN         PER TRAIN

 INCONEL         0.1533E+04         91             4
 CORTEN          0.9823E+03         91             2
 TOTAL           0.2516E+04         91             6
```

Reproduced from
best available copy.

500 MW

```
WATER BALANCE INPUTS
----- ------- ------

  RAINFALL(IN/YEAR)                    50.
  POND SEEPAGE(CM/SEC)*10**8           50.
  POND EVAPORATION(IN/YEAR)            32.


WATER BALANCE OUTPUTS
----- ------- -------

WATER AVAILABLE

  RAINFALL                            879. GPM              439534. LB/HR
  ALKALI                                5. GPM                2304. LB/HR
       TOTAL                          884. GPM              441838. LB/HR


WATER REQUIRED

  HUMIDIFICATION                      464. GPM              231695. LB/HR
  ENTRAINMENT                          11. GPM                5630. LB/HR
  DISPOSAL WATER                      222. GPM              110878. LB/HR
  HYDRATION WATER                      12. GPM                5983. LB/HR
  CLARIFIER EVAPORATION                 0. GPM                   0. LB/HR
  POND EVAPORATION                    599. GPM              299417. LB/HR
  SEEPAGE                             109. GPM               54571. LB/HR

  TOTAL WATER REQUIRED               1417. GPM              708175. LB/HR

NET WATER REQUIRED                    533. GPM              266337. LB/HR
```

```
SCRUBBER SYSTEM
-------- ------

TOTAL NUMBER OF SCRUBBING TRAINS (OPERATING+REDUNDANT) =  5

SO2 REMOVAL =  90.0 PERCENT

PARTICULATE REMOVAL IN SCRUBBER SYSTEM =  50.0 PERCENT

TCA PRESSURE DROP ACROSS  3 BEDS =  8.6 IN. H2O

TOTAL SYSTEM PRESSURE DROP = 14.7 IN. H2O

OVERRIDE TOTAL SYSTEM PRESSURE DROP = 20.0 IN. H2O

SPECIFIED   LIQUID-TO-GAS-RATIO    =  55. GAL/1000 ACF(SATD)

LIMESTONE ADDITION = 0.4607E+05 LB/HR DRY LIMESTONE

SPECIFIED  LIMESTONE STOICHIOMETRY  =  1.25 MOLE CACO3 ADDED AS LIMESTONE
                                            PER MOLE (SO2+2HCL) ABSORBED

SOLUBLE CAO FROM FLY ASH =  0.0  MOLE PER MOLE (SO2+2HCL) ABSORBED

TOTAL SOLUBLE MGO        =  0.0  MOLE PER MOLE (SO2+2HCL) ABSORBED

TOTAL STOICHIOMETRY      =  1.25 MOLE SOLUBLE (CA+MG)
                                 PER MOLE (SO2+2HCL) ABSORBED

SCRUBBER INLET LIQUOR PH =  5.66

MAKE UP WATER =  533. GPM

CROSS-SECTIONAL AREA PER SCRUBBER =   463. SQ FT


SYSTEM SLUDGE DISCHARGE
------ ------ ---------
                                                SOLID   LIQUID
                                                COMP,   COMP,
SPECIES         LB-MOLE/HR     LB/HR            WT %    PPM

CASO3 .1/2 H2O  0.2465E+03     0.3184E+05       52.92
CASO4 .2H2O     0.1044E+03     0.1797E+05       29.88
CACO3           0.8942E+02     0.8951E+04       14.88
INSOLUBLES      ----------     0.1387E+04        2.31
H2O             0.6154E+04     0.1109E+06
CA++            0.6921E+01     0.2774E+03               2484.
MG++            0.0            0.0                         0.
SO3--           0.1818E+00     0.1456E+02                130.
SO4--           0.1297E+01     0.1246E+03               1116.
CL-             0.1098E+02     0.3857E+03               3453.


TOTAL DISCHARGE FLOW RATE = 0.1718E+06 LB/HR
                          =  270.      GPM

TOTAL DISSOLVED SOLIDS IN DISCHARGE LIQUID =   7169. PPM

DISCHARGE LIQUID PH =  7.37
```

500 MW

```
SCRUBBER SLURRY BLEED
-------- ------ -----

SPECIES              LB-MOLE/HR   LB/HR

CASO3 .1/2 H2O       0.2465E+03   0.3183E+05
CASO4 .2H2O          0.1044E+03   0.1797E+05
CACO3                0.8942E+02   0.8951E+04
INSOLUBLES           ----------   0.1387E+04
H2O                  0.1878E+05   0.3383E+06
CA++                 0.2112E+02   0.8465E+03
MG++                 0.0          0.0
SO3--                0.5548E+00   0.4442E+02
SO4--                0.3938E+01   0.3783E+03
CL-                  0.3320E+02   0.1177E+04
AD=                  0.0          0.0

TOTAL FLOW RATE = 0.4009E+06 LB/HR
                =    720.     GPM

TOTAL SUPERNATE RETURN
----- --------- ------

SPECIES              LB-MOLE/HR   LB/HR

H2O                  0.1734E+05   0.3124E+06
CA++                 0.1950E+02   0.7815E+03
MG++                 0.0          0.0
SO3--                0.5123E+00   0.4101E+02
SO4--                0.3655E+01   0.3511E+03
CL-                  0.3065E+02   0.1087E+04
AD=                  0.0          0.0

TOTAL FLOW RATE = 0.3146E+06 LB/HR
                =    630.     GPM

SUPERNATE TO WET BALL MILL
--------- -- --- ---- ----

SPECIES              LB-MOLE/HR   LB/HR

H2O                  0.1582E+04   0.2851E+05
CA++                 0.1779E+01   0.7132E+02
MG++                 0.0          0.0
SO3--                0.4675E-01   0.3743E+01
SO4--                0.3336E+00   0.3204E+02
CL-                  0.2797E+01   0.9917E+02
AD=                  0.0          0.0

TOTAL FLOW RATE = 0.2871E+05 LB/HR
                =     57.     GPM
```

```
LIMESTONE SLURRY FEED
--------- ------ ----

SPECIES              LB-MOLE/HR    LB/HR

CACO3                0.4471E+03    0.4476E+05
SOLUBLE MGO          0.0           0.0
INSOLUBLES           ----------    0.1313E+04
H2O                  0.1693E+04    0.3049E+05
CA++                 0.1779E+01    0.7132E+02
MG++                 0.0           0.0
SO3--                0.4675E-01    0.3743E+01
SO4--                0.3336E+00    0.3204E+02
CL-                  0.2797E+01    0.9917E+02
AD=                  0.0           0.0

TOTAL FLOW RATE = 0.7678E+05 LB/HR
                =      97.     GPM


SUPERNATE RETURN TO SCRUBBER OR EHT
--------- ------ -- -------- -- ---

SPECIES              LB-MOLE/HR    LB/HR

H2O                  0.1576E+05    0.2839E+06
CA++                 0.1772E+02    0.7101E+03
MG++                 0.0           0.0
SO3--                0.4659E+00    0.3727E+02
SO4--                0.3321E+01    0.3190E+03
CL-                  0.2785E+02    0.9874E+03
AD=                  0.0           0.0

TOTAL FLOW RATE = 0.2859E+06 LB/HR
                =     572.     GPM


RECYCLE SLURRY TO SCRUBBER
------- ------ -- --------

SPECIES              LB-MOLE/HR    LB/HR

CASO3 .1/2 H2O       0.2584E+05    0.3336E+07
CASO4 .2H2O          0.1095E+05    0.1884E+07
CACO3                0.9373E+04    0.9382E+06
INSOLUBLES           ----------    0.1453E+06
H2O                  0.1969E+07    0.3546E+08
CA++                 0.2213E+04    0.8872E+05
MG++                 0.0           0.0
SO3--                0.5815E+02    0.4656E+04
SO4--                0.4149E+03    0.3986E+05
CL-                  0.3480E+04    0.1234E+06
AD=                  0.0           0.0

TOTAL FLOW RATE = 0.4202E+08 LB/HR
                =   76321.     GPM
```

500 MW

```
FLUE GAS COOLING SLURRY
---- --- ------- ------

SPECIES            LB-MOLE/HR    LB/HR

CASO3 ,1/2 H2O     0.1879E+04    0.2426E+06
CASO4 .2H2O        0.7960E+03    0.1370E+06
CACO3              0.6817E+03    0.6824E+05
INSOLUBLES         ----------    0.1057E+05
H2O                0.1432E+06    0.2579E+07
CA++               0.1610E+03    0.6452E+04
MG++               0.0           0.0
SO3--              0.4229E+01    0.3386E+03
SO4--              0.3018E+02    0.2899E+04
CL-                0.2531E+03    0.8971E+04
AD=                0.0           0.0

TOTAL FLOW RATE =  0.3056E+07 LB/HR
                =    5551.    GPM
```

500 MW

```
                         POND DESIGN
                         ---- ------

   OPTIMIZED TO MINIMIZE TOTAL COST PLUS OVERHEAD


   POND DIMENSIONS
   ---- ----------

   DEPTH OF POND                      22.81 FT
   DEPTH OF EXCAVATION                 4.02 FT
   LENGTH OF POND PERIMETER        15484.   FT
   LENGTH OF DIVIDER                2819.   FT
   LENGTH PERIMETER FENCE          16510.   FT

   AREA OF BOTTOM                   1486.   THOUSAND YD2
   AREA OF INSIDE WALLS              164.   THOUSAND YD2
   AREA OF OUTSIDE WALLS             123.   THOUSAND YD2
   AREA OF RECLAIM STORAGE           122.   THOUSAND YD2
   AREA OF POND                     1648.   THOUSAND YD2
   AREA OF POND SITE                2015.   THOUSAND YD2
   AREA OF POND SITE                 416.   ACRES

   VOLUME OF EXCAVATION             2183.   THOUSAND YD3
   VOLUME OF RECLAIM STORAGE         928.   THOUSAND YD3
   VOLUME OF SLUDGE TO BE          11935.   THOUSAND YD3
   DISPOSED OVER LIFE OF PLANT      7398.   ACRE FT


   POND COSTS (THOUSANDS OF DOLLARS)
   ---- ----- ---------- -- --------

                                   LABOR    MATERIAL   TOTAL
                                   -----    --------   -----

   CLEARING LAND                    674.                674.
   EXCAVATION                      5424.               5424.
   DIKE CONSTRUCTION               2711.               2711.
   LINING( 12. IN. CLAY)           1650.               1650.
   SODDING DIKE WALLS               105.       69.      174.
   ROAD CONSTRUCTION                 44.       13.       57.
   PERIMETER COSTS, FENCE+           83.      165.      248.
   RECLAIMATION EXPENSE            1113.               1113.
   MONITOR WELLS                      4.        4.        8.
   ---------------------------------------------------------
   POND CONSTRUCTION              11807.      251.    12059.
   LAND COST                                           2081.
   ---------------------------------------------------------
   POND SITE                                          14140.
   OVERHEAD                                           10298.
   ---------------------------------------------------------
   TOTAL                                              24438.
```

EXAMPLE UTILITY, LIMESTONE, NEW ECONOMIC PREMISES CASE 007

PARTICULATE REMOVAL INVESTMENT AND OPERATING COST

		PARTICULATE EMISSION REGULATION (LB ASH/MILLION BTU):	0.03
MPSUL CONTENT (%):	3.36	FLUE GAS TEMPERATURE (COLD) (F):	300.0
ASH CONTENT (%):	15.10	FLUE GAS TEMPERATURE (HOT) (F):	700.0
BTU RATING:	11700	COST OF ELECTRICITY ($/KWHR):	0.03
BOILER TYPE:	DRY PULVERIZED COAL	COST OF STEAM ($/THOUSAND LB):	2.00
NO. OF SCRUBBERS:	4	FIRST YEAR CAPITAL CHARGE FACTOR:	0.180
SCRUBBER VELOCITY (FT/M):	750.0	BAGHOUSE RATIO (OPER. SQ.FT./ACTUAL SQ.FT.):	0.80
PLANT SIZE (MW):	500	BAG COST ($/SQ.FT.):	0.70
OPERATING HRS/YR:	4731	BAG LIFE(YEARS):	3.00
PUMPING RATE (GAL/1000 ACF):	20.00	FLUE GAS REHEAT TEMPERATURE (F):	175.
SCA RATIO: (ACTUAL SQ.FT./CALC. SQ.FT.)	1.300	CHEMICAL ENGINEERING PLANT INDEX:	265.0

	ELECTROSTATIC PRECIPITATORS			
	COLD	HOT	BAGHOUSE FABRIC FILTERS	SCRUBBERS
REQUIRED REMOVAL EFFICIENCY (%):	99.70	99.70	99.70	99.70
DRIFT VELOCITY (FT/M):	27.19	20.00		
SPECIFIC COLLECTION AREA (SQ.FT./ACFM):	277.74	377.59		
COLLECTION AREA (SQ.FT.):	468576.7	972309.6	866133.3	
TOTAL CORONA POWER (KW):	663.6	1012.8		
AUXILIARY POWER (KW):	407.4	915.2	490.2	
FAN POWER (KW):	264.0	403.0	1320.1	16039.9
PUMP POWER (KW):				3267.8
TOTAL POWER (KW):	1335.0	2331.0	1810.3	19307.7
OPERATING AIR/CLOTH RATIO:			2.4	
INSTALLED AIR/CLOTH RATIO:			1.9	
REQUIRED PRESSURE DROP (INCHES):	1.0	1.0	5.0	60.8
DIAMETER (FEET):				30
REQUIRED REHEAT (BTU/HR):				64268960.0
STEAM SUPPLY/YR (THOUSAND LB):				337840.4
INSTALLED COST (1979 DOLLARS):	$ 6562679	$ 12176132	$ 16303550	$ 22732816
FIRST YEAR CAPITALIZED COST:	$ 1183469	$ 2195762	$ 2940073	$ 4099484
ANNUAL POWER COST:	$ 183154	$ 319804	$ 248373	$ 2648996
ANNUAL OPERATING AND MAINTENANCE COST (1979 DOLLARS):	$ 112895	$ 169411	$ 73728	$ 1192909
REPLACEMENT COST (1979 DOLLARS):			$ 265128	
ANNUAL REHEAT COST:				$ 675681
TOTAL ANNUAL COST:	$ 1479518	$ 2684977	$ 3527302	$ 8617070
ANNUALIZED COST OF POWER(MILLS/KWHR):	0.63	1.14	1.49	3.64

RAW MATERIAL HANDLING AND PREPARATION

ITEM	DESCRIPTION	NO.	MATERIAL	LABOR
CAR SHAKER AND HOIST	20HP SHAKER 7.5HP HOIST	1	61661.	10801.
CAR PULLER	25HP PULLER, 5HP RETURN	1	54059.	16207.
UNLOADING HOPPER	16FT DIA, 10FT STRAIGHT INCLUDES 6 IN SQ GRATEING	1	13297.	4915.
UNLOADING VIBRATING FEEDER	3.5HP	1	4687.	432.
UNLOADING BELT CONVEYOR	20FT HORIZONTAL, 5HP	1	9809.	1188.
UNLOADING INCLINE BELT CONVEYOR	310FT, 50HP	1	78133.	3996.
UNLOADING PIT DUST COLLECTOR	POLYPROPYLENE BAGTYPE, INCLUDES DUST HOOD	1	9591.	4320.
UNLOADING PIT SUMP PUMP	60GPM, 70FT HEAD, 5HP	1	2071.	648.
STORAGE BELT CONVEYOR	200FT, 5HP	1	62670.	3240.
STORAGE CONVEYOR TRIPPER	30FPM, 1HP	1	23324.	7561.
MOBILE EQUIPMENT	SCRAPPER TRACTOR	1	121633.	0.
RECLAIM HOPPER	7FT WIDE, 4.25FT HT, 2FT WIDE BOTTOM, CS	2	2071.	1350.
RECLAIM VIBRATING FEEDER	3.5HP	2	9373.	864.
RECLAIM BELT CONVEYOR	200FT, 5HP	1	35095.	2376.
RECLAIM INCLINE BELT CONVEYOR	193FT, 40HP	1	51661.	3024.
RECLAIM PIT DUST COLLECTOR	POLYPROPYLENE BAG TYPE	1	6648.	2160.
RECLAIM PIT SUMP PUMP	60GPM, 70FT HEAD, 5HP	1	2071.	648.
RECLAIM BUCKET ELEVATOR	90FT HIGH, 75HP	1	57002.	5509.
FEED BIN	13FT DIA, 21FT STRAIGHT SIDE HT, COVERED, CS	2	24741.	13285.
BIN WEIGH FEEDER	14FT PULLEY CENTERS, 2HP	2	28338.	1270.
GYRATORY CRUSHERS	75HP	2	169807.	3564.
BALL MILL DUST COLLECTORS	POLYPROPYLENE BAG TYPE 2200 CFM, 7.5HP	2	13297.	4320.
BALL MILL	11.5TPH, 155,HP	2	325278.	37290.
MILLS PRODUCT TANK	5500 GAL 10FT DIA, 10FT HT, FLAKEGLASS LINED CS	2	7847.	6049.
MILLS PRODUCT TANK AGITATOR	10HP	2	13079.	3024.

MILLS PRODUCT TANK SLURRY PUMP	48.GPM,60FT HEAD, 2.HP, 2 OPERATING AND 1 SPARES	3	7245.	2268.
SLURRY FEED TANK	51185.GAL, 20.6FT DIA, 20.6FT HT, FLAKFGLASS-LINED CS	1	15700.	12533.
SLURRY FEED TANK AGITATOR	45.HP	1	33805.	2680.
SLURRY FEED TANK PUMPS	24.GPM, 60 FT HEAD, 1.HP, 4 OPERATING AND 4 SPARE	8	15377.	6049.
			---------	---------
TOTAL EQUIPMENT COST			1257368.	161594.

SCRUBBING

INCLUDING 4 OPERATING AND 1 SPARE SCRUBBING TRAINS

ITEM	DESCRIPTION	NO.	MATERIAL	LABOR
I.D. FANS	20.0IN H2O, WITH 1585. HP MOTOR AND DRIVE	5	4415522.	61580.
SHELL			1313456.	
RUBBER LINING			1294623.	
MIST ELIMINATOR			268021.	
SLURRY HEADER AND NOZZLES			326906.	
GRIDS			581105.	
SPHERES			792482.	
TOTAL TCA SCRUBBER COSTS		5	4576593.	320314.
REHEATERS		5	2139716.	129068.
SOOTBLOWERS		60	252858.	151216.
EFFLUENT HOLD TANK	251060.GAL, 35.0FT DIA, 35.0FT HT, FLAKEGLASS-LINED CS	5	260199.	203196.
EFFLUENT HOLD TANK AGITATOR	66.HP	5	348255.	138051.
COOLING SPRAY PUMPS	1388.GPM 100FT HEAD, 64.HP, 4 OPERATING AND 6 SPARE	10	89798.	26735.
ABSORBER RECYCLE PUMPS	9540.GPM, 100FT HEAD, 442.HP, 8 OPERATING AND 7 SPARE	15	866250.	93129.
MAKEUP WATER PUMPS	2775.GPM, 200.FT HEAD, 234.HP, 1 OPERATING AND 1 SPARE	2	24300.	2047.
			---------	---------
TOTAL EQUIPMENT COST			12973471.	1125897.

WASTE DISPOSAL

ITEM	DESCRIPTION	NO.	MATERIAL	LABOR
ABSORBER BLEED RECEIVING TANK	62898.GAL, 17.5FT DIA, 35.0FT HT, FLAKGLASS-LINED CS	1	20720.	16554.
ABSORBER BLEED TANK AGITATOR	38.HP	1	23676.	1877.
POND FEED SLURRY PUMPS	728.GPM, 130.FT HEAD 44.HP, 1 OPERATING AND 1 SPARE	2	15311.	4034.
POND SUPERNATE PUMPS	630.GPM, 192.FT HEAD, 51.HP, 1 OPERATING AND 1 SPARE	2	11210.	1222.
			---------	---------
TOTAL EQUIPMENT COST			70917.	23687.

LIMESTONE SLURRY PROCESS -- BASIS: 500 MW UNIT, 1981 STARTUP

PROJECTED CAPITAL INVESTMENT REQUIREMENTS - EXAMPLE UTILITY, LIMESTONE, NEW ECONOMIC PREMISES CASE 007

	INVESTMENT, THOUSANDS OF 1980 DOLLARS				DISTRIBUTION
	RAW MATERIAL HANDLING AND PREPARATION	SCRUBBING	WASTE DISPOSAL	TOTAL	PERCENT OF DIRECT INVESTMENT
EQUIPMENT					
MATERIAL	1257.	12973.	71.	14302.	32.0
LABOR	162.	1126.	24.	1311.	2.9
PIPING					
MATERIAL	330.	3370.	879.	4579.	10.3
LABOR	148.	660.	290.	1098.	2.5
DUCTWORK					
MATERIAL	0.	2298.	0.	2298.	5.1
LABOR	0.	1854.	0.	1854.	4.2
FOUNDATIONS					
MATERIAL	245.	136.	17.	398.	0.9
LABOR	637.	285.	34.	956.	2.1
POND CONSTRUCTION	0.	0.	12059.	12059.	27.0
STRUCTURAL					
MATERIAL	147.	287.	2.	436.	1.0
LABOR	86.	484.	3.	573.	1.3
ELECTRICAL					
MATERIAL	163.	716.	126.	1006.	2.3
LABOR	410.	1322.	266.	1998.	4.5
INSTRUMENTATION					
MATERIAL	101.	633.	9.	744.	1.7
LABOR	15.	102.	8.	126.	0.3
BUILDINGS					
MATERIAL	33.	0.	0.	33.	0.1
LABOR	36.	0.	0.	36.	0.1
SERVICES AND MISCELLANEOUS	74.	515.	271.	860.	1.9
SUBTOTAL DIRECT INVESTMENT	3844.	26764.	14058.	44666.	100.0
ENGINEERING DESIGN AND SUPERVISION	346.	2409.	1265.	4020.	9.0
CONSTRUCTION EXPENSES	615.	4282.	2249.	7147.	16.0
CONTRACTOR FEES	192.	1338.	703.	2233.	5.0
CONTINGENCY	999.	6959.	3655.	11613.	26.0
SUBTOTAL FIXED INVESTMENT	5996.	41752.	21930.	69679.	156.0
ALLOWANCE FOR STARTUP AND MODIFICATIONS	461.	3212.	1687.	5360.	12.0
INTEREST DURING CONSTRUCTION	899.	6263.	3290.	10452.	23.4
SUBTOTAL CAPITAL INVESTMENT	7356.	51227.	26907.	85491.	191.4
LAND	10.	4.	2093.	2107.	4.7
WORKING CAPITAL	202.	1408.	739.	2349.	5.3
TOTAL CAPITAL INVESTMENT	7568.	52639.	29739.	89947.	201.4

500 MW

```
LIMESTONE SLURRY PROCESS -- BASIS: 500 MW UNIT, 1981 STARTUP

PROJECTED REVENUE REQUIREMENTS - EXAMPLE UTILITY, LIMESTONE, NEW ECONOMIC PREMISES                  CASE 007

                                   DISPLAY SHEET FOR YEAR=    1
                                  ANNUAL OPERATION KW-HR/KW =  4731

                        30.07 TONS PER HOUR                       DRY                  SLUDGE
                              TOTAL CAPITAL INVESTMENT      87267000                       TOTAL
                                                                                          ANNUAL
                                            ANNUAL QUANTITY        UNIT COST,$            COST,$
                                            ---------------        -----------            ------
    DIRECT COSTS
    ------------
      RAW MATERIAL
      ------------
        LIMESTONE                                109.0 K TONS        8.00/TON             871800
                                                                                      ----------
           SUBTOTAL RAW MATERIAL                                                          871800

      CONVERSION COSTS
      ----------------
        OPERATING LABOR AND
          SUPERVISION                          28450.0 MAN-HR       12.50/MAN-HR          355600
        UTILITIES
          STEAM                               414360.0 K LB          2.00/K LB            828700
          PROCESS WATER                       151270.0 K GAL         0.12/K GAL            18200
          ELECTRICITY                       41407580.0 KWH           0.029/KWH           1200800
        MAINTENANCE
          LABOR AND MATERIAL                                                             2970400
        ANALYSES                                4590.0 HR           17.00/HR               78000
                                                                                      ----------
           SUBTOTAL CONVERSION COSTS                                                     5451700

           SUBTOTAL DIRECT COSTS                                                         6323500

    INDIRECT COSTS
    --------------
      OVERHEADS
        PLANT AND ADMINISTRATIVE (  60.0% OF CONVERSION COSTS LESS UTILITIES)            2042400
                                                                                      ----------
      FIRST YEAR OPERATING AND MAINTENANCE COSTS                                         8365900
      LEVELIZED CAPITAL CHARGES(  14.7% OF TOTAL CAPITAL INVESTMENT)                    13222000
                                                                                      ----------
          FIRST YEAR ANNUAL REVENUE REQUIREMENTS                                        21567900

          EQUIVALENT FIRST YEAR UNIT REVENUE REQUIREMENTS, MILLS/KWH                        9.13
--------------------------------------------------------------------------------------------------------------
      LEVELIZED OPERATING AND MAINTENANCE ( 1.886 TIMES FIRST YEAR OPER. & MAIN.)       15778100
      LEVELIZED CAPITAL CHARGES( 11.64% OF TOTAL CAPITAL INVESTMENT)
                                                                                      --13222000
          LEVELIZED ANNUAL REVENUE REQUIREMENTS
                                                                                        29000100
          EQUIVALENT LEVELIZED UNIT REVENUE REQUIREMENTS, MILLS/KWH
                                                                                           12.54
--------------------------------------------------------------------------------------------------------------
      HEAT RATE   9500. BTU/KWH     -     HEAT VALUE OF COAL     11700 BTU/LB     -     COAL RATE    960400 TONS/YR
```

Reproduced from
best available copy.

1000 MW

```
EXAMPLE UTILITY, LIMESTONE, NEW ECONOMIC PREMISES                                CASE 000

                     *** INPUTS ***

BOILER CHARACTERISTICS
------ ---------------

MEGAWATTS =  1000.      UTILITY BASIS - NEW POND BASIS

BOILER HEAT RATE =  9500. BTU/KWH

EXCESS AIR =  39. PERCENT, INCLUDING LEAKAGE

HOT GAS TEMPERATURE = 300. DEG F

COAL ANALYSIS, WT % AS FIRED :

  C      H      O      N      S      CL    ASH    H2O
66.70  3.90   5.90   1.30   3.30   0.10  17.10   5.00

SULFUR OVERHEAD =  92.0 PERCENT

ASH OVERHEAD =  80.0 PERCENT

HEATING VALUE OF COAL = 11700. BTU/LB

                           EFFICIENCY,    EMISSION,
FLYASH REMOVAL                 %          LBS/M BTU
------ -------           ------------   ---------

UPSTREAM OF SCRUBBER         99.7           0.03

WITHIN SCRUBBER              50.0           0.02

COST OF UPSTREAM FLYASH REMOVAL EXCLUDED


ALKALI
------

LIMESTONE :

      CACO3         =  97.15 WT % DRY BASIS
      SOLUBLE MGO =    0.0
      INERTS        =   2.85
      MOISTURE CONTENT =   5.00 LB H2O/100 LBS DRY LIMESTONE
      LIMESTONE HARDNESS WORK INDEX FACTOR = 10.00
      LIMESTONE DEGREE OF GRIND FACTOR =  1.33

FLY ASH :

      SOLUBLE CAO =   0.0  WT %
      SOLUBLE MGO =   0.0
      INERTS       = 100.00


RAW MATERIAL HANDLING DATA
--- -------- -------- ----

NUMBER OF REDUNDANT ALKALI PREPARATION UNITS =    0
```

```
SCRUBBER SYSTEM VARIABLES
-------- ------ ---------

NUMBER OF OPERATING SCRUBBING TRAINS =   8

NUMBER OF REDUNDANT SCRUBBING TRAINS =   2

NUMBER OF BEDS =   3

NUMBER OF GRIDS =   4

HEIGHT OF SPHERES PER BED =  5.0 INCHES

LIQUID-TO-GAS RATIO =  55. GAL/1000 ACF(SATD)

SCRUBBER GAS VELOCITY = 12.5 FT/SEC

INDUCED DRAFT SCRUBBER FAN OPTION

SCRUBBER PRESSURE = 14.7 PSIA

STOICHIOMETRY =  1.25 MOLE CACO3 ADDED AS LIMESTONE
                      PER MOLE (SO2+2HCL) ABSORBED

SO2 REMOVAL =  90. PERCENT

ENTRAINMENT LEVEL = 0.10 WT %

EHT RESIDENCE TIME =  12.0 MIN

SO2 OXIDIZED IN SYSTEM =  30.0 PERCENT

SOLIDS IN RECIRCULATED SLURRY =  15.0 WT %


SOLIDS DISPOSAL SYSTEM
------ -------- ------

COST OF LAND =  9000.00 DOLLARS/ACRE

SOLIDS IN SYSTEM SLUDGE DISCHARGE =  35.0 WT %

MAXIMUM POND AREA =  9999. ACRES

MAXIMUM EXCAVATION =  25.00 FT

DISTANCE TO POND =  5280. FT

POND LINED WITH 12.0 INCHES CLAY


STEAM REHEATER (IN-LINE)
----- -------- ---------

SATURATED STEAM TEMPERATURE =  470. DEG F

HEAT OF VAPORIZATION OF STEAM =  751. BTU/LB

OUTLET FLUE GAS TEMPERATURE = 175. DEG F

SUPERFICIAL GAS VELOCITY (FACE VELOCITY) =  25.0 FT/SEC
```

Reproduced from
best available copy.

1000 MW

```
     EXAMPLE UTILITY, LIMESTONE, NEW ECONOMIC PREMISES                          CASE 004

                              *** OUTPUTS ***

   HOT GAS TO SCRUBBER
   --- --- -- --------

            MOLE PERCENT      LB-MOLE/HR      LB/HR

   CO2        12.338          0.4509E+05      0.1985E+07
   HCL         0.006          0.2290E+02      0.8351E+03
   SO2         0.214          0.7829E+03      0.5015E+05
   O2          5.560          0.2032E+05      0.6502E+06
   N2         75.227          0.2749E+06      0.7704E+07
   H2O         6.654          0.2432E+05      0.4381E+06

   SO2 CONCENTRATION IN SCRUBBER INLET GAS = 2142. PPM
                                           = 5.28 LBS / MILLION BTU

   FLYASH EMISSION =  0.03 LBS/MILLION BTU
                   =  0.015 GRAINS/SCF (WET)  OR    294. LB/HR

         SOLUBLE CAO IN FLY ASH =     0. LB/HR
         SOLUBLE MGO IN FLY ASH =     0.

   HOT GAS FLOW RATE =  .2309E+07 SCFM (60 DEG F, 14.7 PSIA)
                     =  .3374E+07 ACFM (300. DEG F, 14.7 PSIA)

   CORRESPONDING COAL FIRING RATE =  .8120E+06 LB/HR

   HOT GAS HUMIDITY =  0.042 LB H2O/LB DRY GAS

   WET BULB TEMPERATURE = 124. DEG F


   WET GAS FROM SCRUBBER
   --- --- ---- --------

            MOLE PERCENT      LB-MOLE/HR      LB/HR

   CO2        11.716          0.4582E+05      0.2017E+07
   HCL         0.000          0.1145E+01      0.4175E+02
   SO2         0.020          0.7829E+02      0.5015E+04
   O2          5.169          0.2021E+05      0.6469E+06
   N2         70.300          0.2749E+06      0.7704E+07
   H2O        12.795          0.5004E+05      0.9015E+06

   SO2 CONCENTRATION IN SCRUBBER OUTLET GAS =  200. PPM

   FLYASH EMISSION =  0.02 LBS/MILLION BTU
                   =  0.007 GRAINS/SCF (WET)  OR    147. LB/HR

   TOTAL WATER PICKUP =  950.  GPM
             INCLUDING   22.5 GPM ENTRAINMENT

   WET GAS FLOW RATE =  .2470E+07 SCFM (60 DEG F, 14.7 PSIA)
                     =  .2775E+07 ACFM (124. DEG F, 14.7 PSIA)

   WET GAS SATURATION HUMIDITY =  0.047 LB H2O/LB DRY GAS
```

FLUE GAS TO STACK

```
                MOLE PERCENT     LB-MOLE/HR      LB/HR

     CO2           11.697        0.4582E+05     0.2017E+07
     HCL            0.000        0.1145E+01     0.4175E+02
     SO2            0.020        0.7829E+02     0.5015E+04
     O2             5.159        0.2021E+05     0.6469E+06
     N2            70.183        0.2749E+06     0.7704E+07
     H2O           12.934        0.5067E+05     0.9120E+06

     SPFCIFIED  SO2 REMOVAL EFFICIENCY =  90.0 %

     CALCULATED SO2 EMISSION =   0.53 POUNDS PER MILLION BTU

     CALCULATED SO2 CONCENTRATION IN STACK GAS =     200. PPM

     FLYASH EMISSION =  0.02 LBS/MILLION BTU
                     =  0.007 GRAINS/SCF (WET)  OR    147. LB/HR

     STACK GAS FLOW RATE =  .2474E+07 SCFM (60 DEG F, 14.7 PSIA)
                         =  .3022E+07 ACFM (175. DEG F, 14.7 PSIA)


     STEAM REHEATER (IN-LINE)
     ----- -------- ---------

     SUPERFICIAL GAS VELOCITY (FACE VELOCITY) =  25.0 FT/SEC

     SQUARE PIPE PITCH = 2 TIMES ACTUAL PIPE O.D.

     SATURATED STEAM TEMPERATURE =  470. DEG F

     OUTLET FLUE GAS TEMPERATURE = 175. DEG F

     REQUIRED HEAT INPUT TO REHEATER = 0.1316E+09 BTU/HR

     STEAM CONSUMPTION = 0.1752E+06 LBS/HR


                                       HEAT TRANSFER
     OUTSIDE PIPE   PRESSURE DROP,     COEFFICIENT,
     DIAMETER, IN.  IN. H2O            BTU/HR FT2 DEG F
       1.00             0.65             0.2098E+02


                      REHEATER         NUMBER OF
                      OUTSIDE PIPE     PIPES PER     NUMBER OF
                      AREA, SQ FT      BANK PER      BANKS (ROWS)
                      PER TRAIN        TRAIN         PER TRAIN

     INCONEL          0.1573E+04          91             4
     CORTEN           0.8423E+03          91             2
     TOTAL            0.2416E+04          91             6
```

Reproduced from best available copy.

1000 MW

```
WATER BALANCE INPUTS
----- ------- ------

  RAINFALL(IN/YEAR)                      50.
  POND SEEPAGE(CM/SEC)*10**8             50.
  POND EVAPORATION(IN/YEAR)              32.


WATER BALANCE OUTPUTS
----- ------- -------

WATER AVAILABLE

  RAINFALL                             1545. GPM              772120. LB/HR
  ALKALI                                  9. GPM                4607. LB/HR
       TOTAL                           1554. GPM              776727. LB/HR


WATER REQUIRED

  HUMIDIFICATION                        927. GPM              463391. LB/HR
  ENTRAINMENT                            23. GPM               11260. LB/HR
  DISPOSAL WATER                        444. GPM              221757. LB/HR
  HYDRATION WATER                        24. GPM               11966. LB/HR
  CLARIFIER EVAPORATION                   0. GPM                   0. LB/HR
  POND EVAPORATION                     1061. GPM              530386. LB/HR
  SEEPAGE                               192. GPM               95865. LB/HR

  TOTAL WATER REQUIRED                 2670. GPM             1334625. LB/HR

NET WATER REQUIRED                     1114. GPM              557898. LB/HR
```

1000 MW

```
SCRUBBER SYSTEM
-------- ------

TOTAL NUMBER OF SCRUBBING TRAINS (OPERATING+REDUNDANT) = 10

SO2 REMOVAL =  90.0 PERCENT

PARTICULATE REMOVAL IN SCRUBBER SYSTEM =  50.0 PERCENT

TCA PRESSURE DROP ACROSS  3 BEDS =  4.6 IN. H2O

TOTAL SYSTEM PRESSURE DROP = 14.7 IN. H2O

OVERRIDE TOTAL SYSTEM PRESSURE DROP = 20.0 IN. H2O

SPECIFIED   LIQUID-TO-GAS-RATIO    =  55. GAL/1000 ACF(SATD)

LIMESTONE ADDITION = 0.9214E+05 LB/HR DRY LIMESTONE

SPECIFIED  LIMESTONE STOICHIOMETRY  =  1.25 MOLE CACO3 ADDED AS LIMESTONE
                                           PER MOLE (SO2+2HCL) ABSORBED

SOLUBLE CAO FROM FLY ASH =  0.0  MOLE PER MOLE (SO2+2HCL) ABSORBED

TOTAL SOLUBLE MGO        =  0.0  MOLE PER MOLE (SO2+2HCL) ABSORBED

TOTAL STOICHIOMETRY      =  1.25 MOLE SOLUBLE (CA+MG)
                                 PER MOLE (SO2+2HCL) ABSORBED

SCRUBBER INLET LIQUOR PH =  5.66

MAKE UP WATER = 1116. GPM

CROSS-SECTIONAL AREA PER SCRUBBER =   463. SQ FT


SYSTEM SLUDGE DISCHARGE
------ ------ ---------                          SOLID    LIQUID
                                                 COMP,    COMP,
SPECIES          LB-MOLE/HR    LB/HR             WT %     PPM

CASO3 .1/2 H2O   0.4930E+03    0.6365E+05        52.92
CASO4 .2H2O      0.2088E+03    0.3594E+05        29.88
CACO3            0.1788E+03    0.1790E+05        14.88
INSOLUBLES       ----------    0.2773E+04         2.31
H2O              0.1231E+05    0.2218E+06
CA++             0.1384E+02    0.5548E+03                  2484.
MG++             0.0           0.0                            0.
SO3--            0.3637E+00    0.2911E+02                   130.
SO4--            0.2595E+01    0.2492E+03                  1116.
CL-              0.2176E+02    0.7714E+03                  3453.


TOTAL DISCHARGE FLOW RATE = 0.3436E+06 LB/HR
                          =   560.     GPM

TOTAL DISSOLVED SOLIDS IN DISCHARGE LIQUID =   7169. PPM

DISCHARGE LIQUID PH =  7.37
```

Reproduced from
best available copy.

1000 MW

```
SCRUBBER SLURRY BLEED
-------- ------ -----

SPECIES             LB-MOLE/HR    LB/HR

CASO3 .1/2 H2O      0.4930E+03    0.6365E+05
CASO4 .2H2O         0.2088E+03    0.3594E+05
CACO3               0.1789E+03    0.1790E+05
INSOLUBLES          ----------    0.2773E+04
H2O                 0.3756E+05    0.6766E+06
CA++                0.4223E+02    0.1693E+04
MG++                0.0           0.0
SO3--               0.1110E+01    0.8884E+02
SO4--               0.7917E+01    0.7605E+03
CL-                 0.6639E+02    0.2354E+04
AD=                 0.0           0.0

TOTAL FLOW RATE = 0.8018E+06 LB/HR
                =   1456.    GPM


TOTAL SUPERNATE RETURN
----- --------- ------

SPECIES             LB-MOLE/HR    LB/HR

H2O                 0.3329E+05    0.5997E+06
CA++                0.3743E+02    0.1500E+04
MG++                0.0           0.0
SO3--               0.9835E+00    0.7874E+02
SO4--               0.7017E+01    0.6740E+03
CL-                 0.5804E+02    0.2056E+04
AD=                 0.0           0.0

TOTAL FLOW RATE = 0.6040E+06 LB/HR
                =   1209.    GPM


SUPERNATE TO WET BALL MILL
--------- -- --- ---- ----

SPECIES             LB-MOLE/HR    LB/HR

H2O                 0.3137E+04    0.5652E+05
CA++                0.3523E+01    0.1414E+03
MG++                0.0           0.0
SO3--               0.9269E-01    0.7421E+01
SO4--               0.6613E+00    0.6352E+02
CL-                 0.5546E+01    0.1966E+03
AD=                 0.0           0.0

TOTAL FLOW RATE = 0.5693E+05 LB/HR
                =    114.    GPM
```

1000 MW

```
LIMESTONE SLURRY FEED
--------- ------ ----

SPECIES              LB-MOLE/HR    LB/HR

CACO3                0.8943E+03    0.8932E+05
SOLUBLE MGO          0.0           0.0
INSOLUBLES           ----------    0.2625E+04
H2O                  0.3385E+04    0.6099E+05
CA++                 0.3528E+01    0.1414E+03
MG++                 0.0           0.0
SO3--                0.9269E-01    0.7421E+01
SO4--                0.6613E+00    0.6352E+02
CL-                  0.5546E+01    0.1966E+03
AD=                  0.0           0.0

TOTAL FLOW RATE = 0.1536E+06 LB/HR
                =     194.     GPM


SUPERNATE RETURN TO SCRUBBER OR ENT
--------- ------ -- -------- -- ---

SPECIES              LB-MOLE/HR    LB/HR

H2O                  0.3015E+05    0.5432E+06
CA++                 0.3390E+02    0.1359E+04
MG++                 0.0           0.0
SO3--                0.8908E+00    0.7132E+02
SO4--                0.6355E+01    0.6105E+03
CL-                  0.5330E+02    0.1889E+04
AD=                  0.0           0.0

TOTAL FLOW RATE = 0.5471E+06 LB/HR
                =    1095.     GPM


RECYCLE SLURRY TO SCRUBBER
------- ------ -- --------

SPECIES              LB-MOLE/HR    LB/HR

CASO4 .1/2 H2O       0.5169E+05    0.6672E+07
CASO4 .2H2O          0.2189E+05    0.3767E+07
CACO3                0.1875E+05    0.1876E+07
INSOLUBLES           ----------    0.2907E+06
H2O                  0.3937E+07    0.7093E+08
CA++                 0.4427E+04    0.1774E+06
MG++                 0.0           0.0
SO3--                0.1163E+03    0.9312E+04
SO4--                0.8298E+03    0.7971E+05
CL-                  0.6959E+04    0.2467E+06
AD=                  0.0           0.0

TOTAL FLOW RATE = 0.8404E+08 LB/HR
                = 152643.      GPM
```

```
FLUE GAS COOLING SLURRY
---- --- ------- ------

SPECIES              LB-MOLE/HR    LB/HR

CASO3 .1/2 H2O       0.3757E+04    0.4852E+06
CASO4 .2H2O          0.1592E+04    0.2740E+06
CACO3                0.1363E+04    0.1365E+06
INSOLUBLES           ----------    0.2114E+05
H2O                  0.2863E+06    0.5158E+07
CA++                 0.3220E+03    0.1290E+05
MG++                 0.0           0.0
SO3--                0.8459E+01    0.6772E+03
SO4--                0.6035E+02    0.5797E+04
CL-                  0.5061E+03    0.1794E+05
AN=                  0.0           0.0

TOTAL FLOW RATE = 0.6112E+07 LB/HR
                =  11101.     GPM
```

1000 MW

```
                     POND DESIGN
                     ---- ------

   OPTIMIZED TO MINIMIZE TOTAL COST PLUS OVERHEAD


   POND DIMENSIONS
   ---- ----------

   DEPTH OF POND                       25.75 FT
   DEPTH OF EXCAVATION                  3.86 FT
   LENGTH OF POND PERIMETER         23497.    FT
   LENGTH OF DIVIDER                 3792.    FT
   LENGTH PERIMETER FENCE           21604.    FT

   AREA OF BOTTOM                    2659.    THOUSAND YD2
   AREA OF INSIDE WALLS               240.    THOUSAND YD2
   AREA OF OUTSIDE WALLS              187.    THOUSAND YD2
   AREA OF RECLAIM STORAGE            188.    THOUSAND YD2
   AREA OF POND                      2895.    THOUSAND YD2
   AREA OF POND SITE                 3429.    THOUSAND YD2
   AREA OF POND SITE                  709.    ACRES

   VOLUME OF EXCAVATION              3695.    THOUSAND YD3
   VOLUME OF RECLAIM STORAGE         1597.    THOUSAND YD3
   VOLUME OF SLUDGE TO BE           23670.    THOUSAND YD3
   DISPOSED OVER LIFE OF PLANT      14795.    ACRE FT


   POND COSTS (THOUSANDS OF DOLLARS)
   ---- ----- ---------- -- --------

                                    LABOR     MATERIAL   TOTAL
                                    -----     --------   -----

   CLEARING LAND                    1148.                1148.
   EXCAVATION                       9186.                9186.
   DIKE CONSTRUCTION                4538.                4538.
   LINING( 12. IN. CLAY)            2900.                2900.
   SODDING DIKE WALLS                157.       102.      259.
   ROAD CONSTRUCTION                  58.        18.       76.
   PERIMETER COSTS, FENCE+           108.       216.      324.
   RECLAIMATION EXPENSE             1894.                1894.
   MONITOR WELLS                       4.         4.        8.
   -----------------------------------------------------------
   POND CONSTRUCTION               19993.       340.    20333.
   LAND COST                                             3543.
   -----------------------------------------------------------
   POND SITE                                            23876.
   OVERHEAD                                             17365.
   -----------------------------------------------------------
   TOTAL                                                41241.
```

Reproduced from
best available copy.

1000 MW

```
EXAMPLE UTILITY, LIMESTONE, NEW ECONOMIC PREMISES                    CASE 008

                              PARTICULATE REMOVAL INVESTMENT AND OPERATING COST
                                                       PARTICULATE EMISSION REGULATION (LB ASH/MILLION BTU):   0.03
 WPSUL CONTENT (%):            3.36                    FLUE GAS TEMPERATURE (COLD) (F):                      300.0
 ASH CONTENT (%):             15.10                    FLUE GAS TEMPERATURE (HOT) (F):                       700.0
 BTU RATING:                  11700                    COST OF ELECTRICITY ($/KWHR):                           0.03
 BOILER TYPE:                 DRY PULVERIZED COAL      COST OF STEAM ($/THOUSAND LB):                          2.00
 NO. OF SCRUBBERS:                8                    FIRST YEAR CAPITAL CHARGE FACTOR:                       0.180
 SCRUBBER VELOCITY (FT/M):    750.0                    BAGHOUSE RATIO (OPER. SQ.FT./ACTUAL SQ.FT.):            0.80
 PLANT SIZE (MW):              1000                    BAG COST ($/SQ.FT.):                                    0.70
 OPERATING HRS/YR:             4731                    BAG LIFE(YEARS):                                      3.00
 PUMPING RATE (GAL/1000 ACF): 20.00                    FLUE GAS REHEAT TEMPERATURE (F):                      175.
 SCA RATIO:                   1.300                    CHEMICAL ENGINEERING PLANT INDEX:                     265.0
   (ACTUAL SQ.FT./CALC. SQ.FT.)



                                           ELECTROSTATIC PRECIPITATORS

                                            COLD           HOT          BAGHOUSE FABRIC FILTERS      SCRUBBERS

 REQUIRED REMOVAL EFFICIENCY (%):          99.70          99.70                  99.70                99.70
 DRIFT VELOCITY (FT/M):                    27.19          20.00
 SPECIFIC COLLECTION AREA (SQ.FT./ACFM):  277.74         377.59
 COLLECTION AREA (SQ.FT.):              937153.9      1944619.0              1732267.0
 TOTAL CORONA POWER (KW):                 1327.1         2025.6
 AUXILIARY POWER (KW):                     878.5         1973.7                  775.8
 FAN POWER (KW):                           528.0          805.9                 2640.2              32079.9
 PUMP POWER (KW):                                                                                    6535.5
 TOTAL POWER (KW):                        2733.7         4805.3                 3415.9              38615.4
 OPERATING AIR/CLOTH RATIO:                                                        2.4
 INSTALLED AIR/CLOTH RATIO:                                                        1.9
 REQUIRED PRESSURE DROP (INCHES):            1.0            1.0                    5.0                 60.8
 DIAMETER (FEET):                                                                                         30
 REQUIRED REHEAT (BTU/HR):                                                                       128538032.
 STEAM SUPPLY/YR (THOUSAND LB):                                                                     675681.5
 INSTALLED COST (1979 DOLLARS):         $ 12109651     $ 22514496             $ 29010704           $ 40588688
 FIRST YEAR CAPITALIZED COST:           $  2183773     $  4060113             $  5231596           $  7319492
 ANNUAL POWER COST:                     $   375064     $   659278             $   468865           $  5297995
 ANNUAL OPERATING AND
  MAINTENANCE COST (1979 DOLLARS):      $   165977     $   249066             $   110662           $  2129900
 REPLACEMENT COST (1979 DOLLARS):                                             $   530257
 ANNUAL REHEAT COST:                                                                               $  1351363


 TOTAL ANNUAL COST:                     $  2724814     $  4968457             $  6341180           $ 16098750
 ANNUALIZED COST OF POWER(MILLS/KWHR):        0.58           1.05                   1.34                 3.40
```

1000 MW

RAW MATERIAL HANDLING AND PREPARATION

ITEM	DESCRIPTION	NO.	MATERIAL	LABOR
CAR SHAKER AND HOIST	20HP SHAKER 7.5HP HOIST	1	61661.	10801.
CAR PULLER	25HP PULLER, 5HP RETURN	1	54059.	16202.
UNLOADING HOPPER	16FT DIA, 10FT STRAIGHT INCLUDES 6 IN SQ GRATEING	1	13297.	4915.
UNLOADING VIBRATING FEEDER	3.5HP	1	4687.	432.
UNLOADING BELT CONVEYOR	20FT HORIZONTAL, 5HP	1	9809.	1188.
UNLOADING INCLINE BELT CONVEYOR	310FT, 50HP	1	73133.	3996.
UNLOADING PIT DUST COLLECTOR	POLYPROPYLENE BAGTYPE, INCLUDES DUST HOOD	1	9391.	4320.
UNLOADING PIT SUMP PUMP	60GPM, 70FT HEAD, 5HP	1	2071.	648.
STORAGE BELT CONVEYOR	300FT, 7HP	1	87465.	4861.
STORAGE CONVEYOR TRIPPER	30FPM, 1HP	1	23324.	7561.
MOBILE EQUIPMENT	SCRAPPER TRACTOR	1	121633.	0.
RECLAIM HOPPER	7FT WIDE, 4.25FT HT, 2FT WIDE BOTTOM, CS	2	3106.	2025.
RECLAIM VIBRATING FEEDER	3.5HP	2	14060.	1296.
RECLAIM BELT CONVEYOR	300FT, 7HP	1	50572.	3564.
RECLAIM INCLINE BELT CONVEYOR	193FT, 40HP	1	51661.	3024.
RECLAIM PIT DUST COLLECTOR	POLYPROPYLENE BAG TYPE	1	6648.	2160.
RECLAIM PIT SUMP PUMP	60GPM, 70FT HEAD, 5HP	1	2071.	648.
RECLAIM BUCKET ELEVATOR	90FT HIGH, 75HP	1	57002.	5509.
FEED BIN	13FT DIA, 21FT STRAIGHT SIDE HT, COVERED, CS	2	24741.	13285.
BIN WEIGH FEEDER	14FT PULLEY CENTERS, 2HP	2	28338.	1296.
GYRATORY CRUSHERS	75HP	2	169807.	3564.
BALL MILL DUST COLLECTORS	POLYPROPYLENE BAG TYPE 2200 CFM, 7.5HP	2	13297.	4320.
BALL MILL	23.0TPH, 311.HP	2	437624.	45602.
MILLS PRODUCT TANK	5500 GAL 10FT DIA, 10FT HT, FLAKEGLASS LINED CS	2	7847.	6049.
MILLS PRODUCT TANK AGITATOR	10HP	2	13070.	3024.

MILLS PRODUCT TANK SLURRY PUMP	97.GPM,60FT HEAD, [illegible],HP, 2 OPERATING AND 1 SPARES	3	10186.	2507.
SLURRY FEED TANK	102370,GAL, 25,9FT DIA, 25,9FT HT, FLAKEGLASS-LINED CS	1	24921,	19894,
SLURRY FEED TANK AGITATOR	72,HP	1	55206,	4377,
SLURRY FEED TANK PUMPS	24,GPM, 60 FT HEAD, 1,HP, 8 OPERATING AND 7 SPARE	15	34458,	11341,
			----------	----------
TOTAL EQUIPMENT COST			1465390,	168611,

1000 MW

SCRUBBING

INCLUDING 8 OPERATING AND 2 SPARE SCRUBBING TRAINS

ITEM	DESCRIPTION	NO.	MATERIAL	LABOR
I.D. FANS	20.0IN H2O, WITH 1585. HP MOTOR AND DRIVE	10	8831051.	123160.
SHELL			2626915.	
RUBBER LINING			2589249.	
MIST ELIMINATOR			536043.	
SLURRY HEADER AND NOZZLES			653813.	
GRIDS			1162211.	
SPHERES			1584964.	
TOTAL TCA SCRUBBER COSTS		10	9153196.	640628.
REHEATERS		10	4279434.	258136.
SOOTBLOWERS		120	505716.	302432.
EFFLUENT HOLD TANK	251861.GAL, 35.0FT DIA, 35.0FT HT, FLAKEGLASS-LINED CS	10	520398.	406312.
EFFLUENT HOLD TANK AGITATOR	66.HP	10	696511.	552204.
COOLING SPRAY PUMPS	1388.GPM 100FT HEAD, 64.HP, 8 OPERATING AND 12 SPARE	20	179596.	53470.
ABSORBER RECYCLE PUMPS	9540.GPM, 100FT HEAD, 442.HP, 16 OPERATING AND 14 SPARE	30	1732501.	186259.
MAKEUP WATER PUMPS	5551.GPM, 200.FT HEAD, 468.HP, 1 OPERATING AND 1 SPARE	2	57353.	6252.
			----------	---------
TOTAL EQUIPMENT COST			25955664.	2528849.

1000 MW

WASTE DISPOSAL

ITEM	DESCRIPTION	NO.	MATERIAL	LABOR
ABSORBER BLEED RECEIVING TANK	62850.GAL, 17.5FT DIA, 35.0FT HT, FLAKGLASS-LINED CS	1	20720.	16894.
ABSORBER BLEED TANK AGITATOR	30.HP	1	23676.	1677.
POND FEED SLURRY PUMPS	1456.GPM, 130.FT HEAD 87.HP, 1 OPERATING AND 1 SPARE	2	20050.	3461.
POND SUPERNATE PUMPS	1209.GPM, 192.FT HEAD, 90.HP, 1 OPERATING AND 1 SPARE	2	14599.	1391.
TOTAL EQUIPMENT COST			79044.	23484.

1000 MW

LIMESTONE SLURRY PROCESS -- BASIS: 1000 MW UNIT, 1981 STARTUP

PROJECTED CAPITAL INVESTMENT REQUIREMENTS - EXAMPLE UTILITY, LIMESTONE, NEW ECONOMIC PREMISES CASE 008

	INVESTMENT, THOUSANDS OF 1980 DOLLARS				DISTRIBUTION
	RAW MATERIAL HANDLING AND PREPARATION	SCRUBBING	WASTE DISPOSAL	TOTAL	PERCENT OF DIRECT INVESTMENT
EQUIPMENT					
MATERIAL	1465.	25956.	79.	27500.	34.1
LABOR	189.	2529.	25.	2743.	3.4
PIPING					
MATERIAL	493.	6707.	1154.	8354.	10.4
LABOR	209.	1303.	348.	1860.	2.3
DUCTWORK					
MATERIAL	0.	4694.	0.	4694.	5.8
LABOR	0.	3827.	0.	3827.	4.8
FOUNDATIONS					
MATERIAL	291.	272.	17.	579.	0.7
LABOR	772.	570.	34.	1376.	1.7
POND CONSTRUCTION	0.	0.	20333.	20333.	25.2
STRUCTURAL					
MATERIAL	177.	575.	2.	754.	0.9
LABOR	93.	968.	4.	1065.	1.3
ELECTRICAL					
MATERIAL	160.	1338.	131.	1628.	2.0
LABOR	362.	2341.	273.	2976.	3.7
INSTRUMENTATION					
MATERIAL	144.	1250.	11.	1405.	1.7
LABOR	22.	204.	8.	234.	0.3
BUILDINGS					
MATERIAL	50.	0.	0.	50.	0.1
LABOR	53.	0.	0.	53.	0.1
SERVICES AND MISCELLANEOUS	63.	738.	315.	1116.	1.4
SUBTOTAL DIRECT INVESTMENT	4541.	53272.	22743.	80556.	100.0
ENGINEERING DESIGN AND SUPERVISION	409.	4794.	2047.	7250.	9.0
CONSTRUCTION EXPENSES	727.	8524.	3639.	12889.	16.0
CONTRACTOR FEES	227.	2664.	1137.	4028.	5.0
CONTINGENCY	1181.	13851.	5913.	20945.	26.0
SUBTOTAL FIXED INVESTMENT	7085.	83105.	35479.	125667.	156.0
ALLOWANCE FOR STARTUP AND MODIFICATIONS	545.	6393.	2729.	9667.	12.0
INTEREST DURING CONSTRUCTION	1063.	12466.	5322.	18850.	23.4
SUBTOTAL CAPITAL INVESTMENT	8693.	101964.	43530.	154184.	191.4
LAND	11.	7.	3555.	3573.	4.4
WORKING CAPITAL	241.	2824.	1206.	4270.	5.3
TOTAL CAPITAL INVESTMENT	8945.	104795.	48291.	162027.	201.1

1000 MW

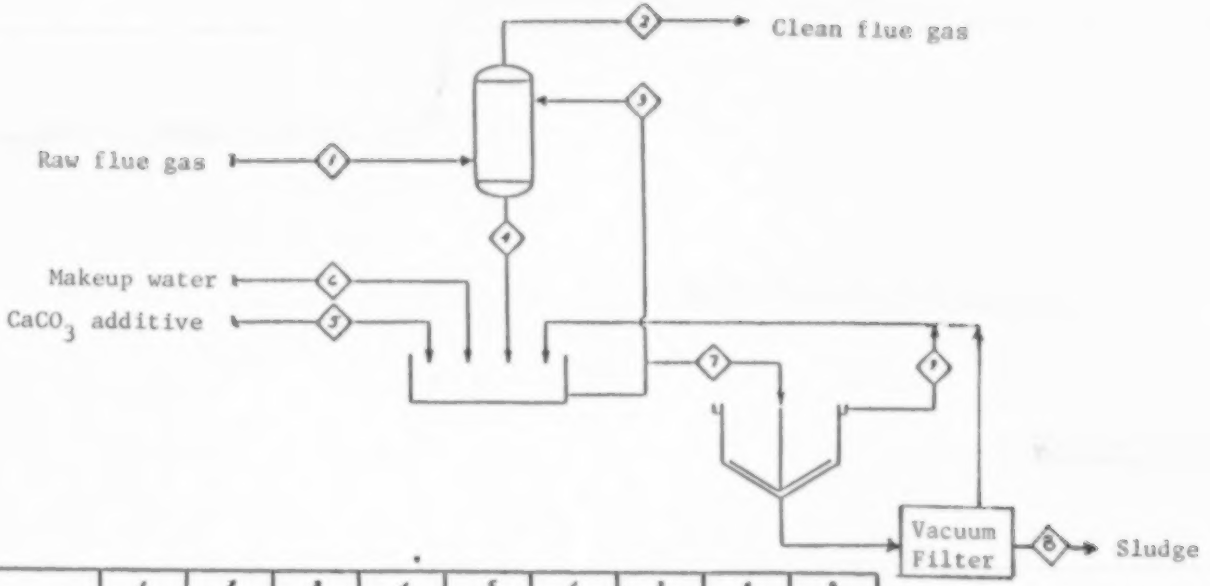
```
LIMESTONE SLURRY PROCESS -- BASIS: 1000 MW UNIT, 1981 STARTUP

PROJECTED REVENUE REQUIREMENTS - EXAMPLE UTILITY, LIMESTONE, NEW ECONOMIC PREMISES                CASE 009

                              DISPLAY SHEET FOR YEAR=    1
                             ANNUAL OPERATION KW-HR/KW =  4731

                 60.13 TONS PER HOUR                               DRY               SLUDGE
                          TOTAL CAPITAL INVESTMENT      157194000                       TOTAL
                                                                                       ANNUAL
                                         ANNUAL QUANTITY        UNIT COST,$            COST,$
                                         ---------------        -----------            ------
       DIRECT COSTS
       ------------
         RAW MATERIAL
         ------------
           LIMESTONE                       218.0 K TONS          8.00/TON             1743700
                                                                                   ----------
              SUBTOTAL RAW MATERIAL                                                   1743700

         CONVERSION COSTS
         ----------------
           OPERATING LABOR AND
             SUPERVISION                 38910.0 MAN-HR        12.50/MAN-HR           486300
           UTILITIES
             STEAM                      828720.0 K LB           2.00/K LB            1657400
             PROCESS WATER              316860.0 K GAL          0.12/K GAL             38000
             ELECTRICITY              80788430.0 KWH            0.029/KWH            2342900
           MAINTENANCE
             LABOR AND MATERIAL                                                       5427800
           ANALYSES                       6110.0 HR            17.00/HR               103900
                                                                                   ----------
              SUBTOTAL CONVERSION COSTS                                             10056300

              SUBTOTAL DIRECT COSTS                                                 11800000

       INDIRECT COSTS
       --------------
         OVERHEADS
           PLANT AND ADMINISTRATIVE (  60.0% OF CONVERSION COSTS LESS UTILITIES)       3610800
                                                                                   ----------
         FIRST YEAR OPERATING AND MAINTENANCE COSTS                                  15410800
         LEVELIZED CAPITAL CHARGES(  14.7% OF TOTAL CAPITAL INVESTMENT)              23817970
                                                                                   ----------
            FIRST YEAR ANNUAL REVENUE REQUIREMENTS                                   39228770

            EQUIVALENT FIRST YEAR UNIT REVENUE REQUIREMENTS, MILLS/KWH                   8.29
-----------------------------------------------------------------------------------------------------------
         LEVELIZED OPERATING AND MAINTENANCE ( 1.886 TIMES FIRST YEAR OPER. & MAIN.)  29064800
         LEVELIZED CAPITAL CHARGES( 11.64% OF TOTAL CAPITAL INVESTMENT)              23817970
                                                                                   ----------
            LEVELIZED ANNUAL REVENUE REQUIREMENTS                                    52882770

            EQUIVALENT LEVELIZED UNIT REVENUE REQUIREMENTS, MILLS/KWH                   11.18
-----------------------------------------------------------------------------------------------------------
         HEAT RATE   9500. BTU/KWH     -     HEAT VALUE OF COAL     11700 BTU/LB     -     COAL RATE   1920700 TONS/YR
```

APPENDIX B

INDUSTRIAL BOILER LIMESTONE FGD SYSTEM PREMISES

MATERIAL BALANCES

EQUIPMENT LIST

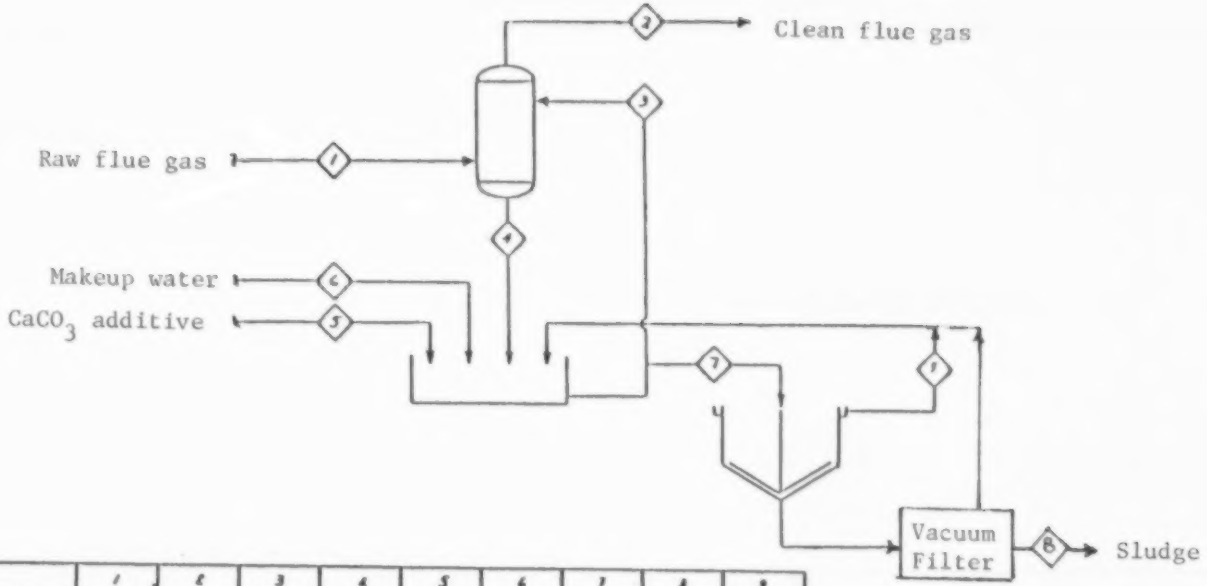

Raw flue gas
Clean flue gas
Makeup water
$CaCO_3$ additive
Vacuum Filter
Sludge
1
2
3
4
5
6
7
8
9

STREAM NUMBER / DESCRIPTION	1 INLET GAS	2 EXIT GAS	3 RECYCLE LIQUOR	4 SCRUBBER BOTTOMS	5 MAKEUP ALKALI	6 MAKEUP WATER	7 CLARIFIER FEED	8 SLUDGE	9 CLARIFIER RETURN
TOTAL FLOW RATE									
(lb/hr)	35,810	38,336	575,870	573,360	281	2998	3960	712	2942
(GPM)	—	—	1037.3	1032	—	6.0		0.7	5.9
TEMPERATURE (°F)	400	125							
GAS FLOW RATE									
(lb/hr)	35,810	38,336							
(lb MOLES/hr)	1234	1379							
(ACFM)	12,900	9800							
(SCFM)	7800	8711							
LIQUID PHASE FLOW RATE									
(lb/hr)			518,270	515,760		2998	3564	356	2902
SOLID PHASE FLOW RATE									
(lb./hr)			57,600	57,600	281		396	356	40

LIMESTONE FGD PROCESS

Boiler size: 30 x 10^6 BTU/Hr.
Coal type: Eastern

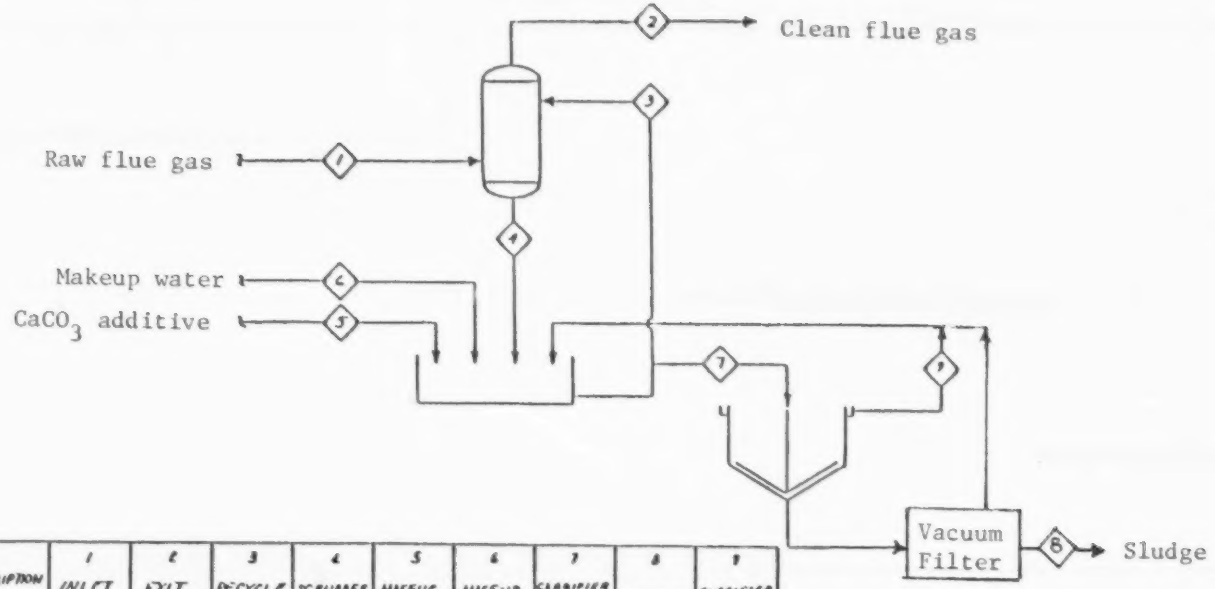
SO_2 Removal: 90%


Clean flue gas
2
3
Raw flue gas
1
4
Makeup water
6
CaCO$_3$ additive
5
7
9
Vacuum Filter
8
Sludge

LIMESTONE FGD PROCESS

Boiler size: 75 x 10^6 BTU/Hr.
Coal type: Eastern
SO_2 removal: 90%

STREAM NUMBER / DESCRIPTION	1 INLET GAS	2 EXIT GAS	3 RECYCLE LIQUOR	4 SCRUBBER BOTTOMS	5 MAKEUP ALKALI	6 MAKEUP WATER	7 FEED	8 SLUDGE	9 RETURN
TOTAL FLOW RATE									
(lb/hr)	89663	96076	1.44×10^6	1.43×10^6	708		9980		7413
(GPM)	—	—	2517	2584	—		18		14.6
TEMPERATURE (°F)	400	125							
GAS FLOW RATE									
(lb/hr)	89663	96,076							
(lb. MOLES/hr)	3091	3456							
(ACFM)	32,300	24559							
(SCFM)	19,530	21830							
LIQUID PHASE FLOW RATE (lb/hr)			1.3×10^6	1.29×10^6			8982		7313
SOLID PHASE FLOW RATE (lb./hr)			144,000	144,000	708		998	898	100

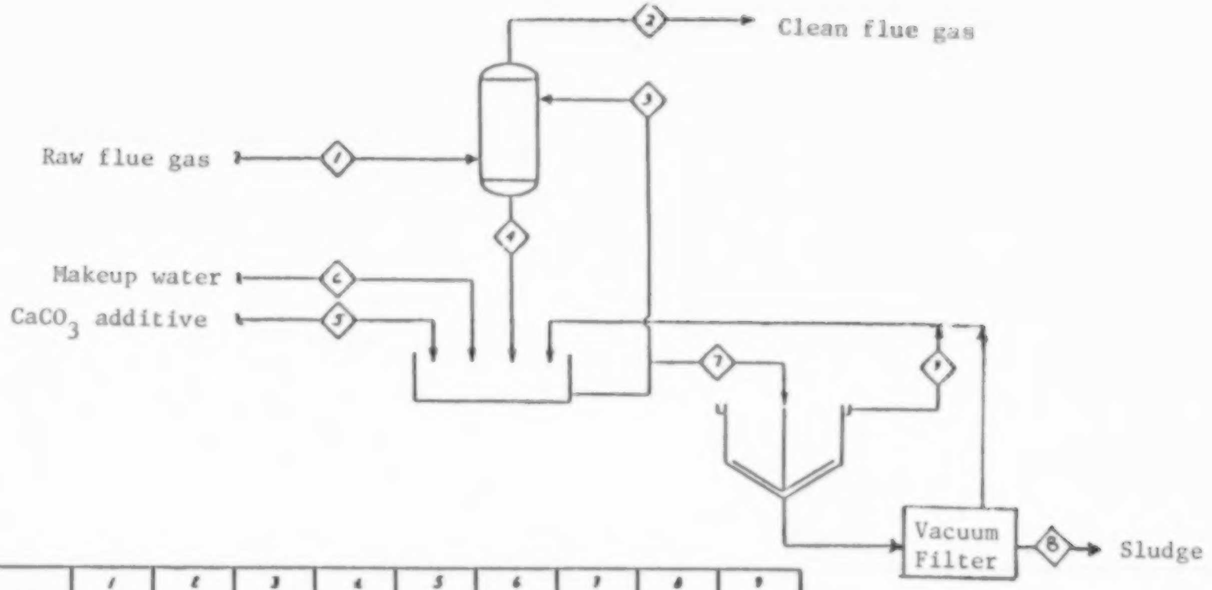

Clean flue gas
Raw flue gas
Makeup water
$CaCO_3$ additive
1
2
3
4
5
6
7
8
9
Vacuum Filter
Sludge

LIMESTONE FGD PROCESS

Boiler size: 150 x 10^6 BTU/Hr.
Coal type: Eastern
SO_2 removal: 90%

STREAM NUMBER / DESCRIPTION	1 INLET GAS	2 EXIT GAS	3 RECYCLE LIQUOR	4 SCRUBBER BOTTOMS	5 MAKEUP ALKALI	6 MAKEUP WATER	7 CLARIFIER FEED	8 SLUDGE	9 CLARIFIER RETURN
TOTAL FLOW RATE									
(lb/hr)	179,882	192,765	2.89×10^6	2.89×10^6	1428	15193	20130	3624	14953
(GPM)	—	—	5211	5184		30.4	36.2	3.6	27.5
TEMPERATURE (°F)	400	125							
GAS FLOW RATE									
(lb/hr)	179,882	192765							
(lb MOLES/hr)	6202	6934							
(ACFM)	64800	49,774							
(SCFM)	39180	43789							
LIQUID PHASE FLOW RATE (lb/hr)			2.6×10^6	2.59×10^6		15193	18117	1812	14752
SOLID PHASE FLOW RATE (lb/hr)			289,373	289,373	1428		2013	1812	201

Reproduced from best available copy.


Clean flue gas
Raw flue gas
Makeup water
CaCO3 additive
Vacuum Filter
Sludge
1
2
3
4
5
6
7
8
9

LIMESTONE FGD PROCESS

Boiler size: 200 x 10^6 BTU/Hr.
Coal type: Eastern
SO_2 removal: 90%

STREAM NUMBER / DESCRIPTION	1 INLET GAS	2 EXIT GAS	3 RECYCLE LIQUOR	4 SCRUBBER BOTTOMS	5 MAKEUP ALKALI	6 MAKEUP WATER	7 CLARIFIER FEED	8 SLUDGE	9 CLARIFIER RETURN
TOTAL FLOW RATE									
(lb/hr)	207640	222489	3.33×10^6	3.32×10^6	1846	17892	26730	4812	17450
(GPM)	—	—	6015	5989	—	35.8	98.1	4.8	34.3
TEMPERATURE (°F)	400	125	—	—	—	—	—	—	—
GAS FLOW RATE									
(lb/hr)	207640	222489							
(lb MOLES/hr)	7160	8003							
(ACFM)	74800	68871							
(SCFM)	45228	50552							
LIQUID PHASE FLOW RATE									
(lb/hr)			3.00×10^6	2.99×10^6		17892	24057	2406	17183
SOLID PHASE FLOW RATE									
(lb/hr)			334000	334000	1896		2673	2406	267

EQUIPMENT LIST - PURCHASED PRICE (1978 Dollars)

LIMESTONE FGD - INDUSTRIAL BOILERS

	8.8 MWt		22 MWt		44 MWt		58.6 MWt	
	Description	$	Description	$	Description	$	Description	$
Raw Material Handling								
Pneumatic Conveyor		3,394		3,394		3,394		3,394
Silo - 2 wt capacity	94.4k lbs	24,000	237.9k lbs	46,000	480.0k lbs	73,000	637.0k lbs	87,000
Screw Feeder		1,193		1,193		1,193		1,193
Mix Tank	30 gal	270	76 gal	390	152 gal	600	179 gal	670
Mixer		190		300		430		460
Feed Pumps - 2	6 gpm	6,000	15.2 gpm	7,200	30.4 gpm	8,400	35.8 gpm	8,700
		35,053		58,477		87,017		101,430
Fans	12,900 acfm	8,900	32,300 acfm	17,500	64,800 acfm	30,000	74,800 acfm	33,000
SO_2 Scrubbing								
Absorber	12,900 acfm	21,000	32,300 acfm	40,000	64,800 acfm	66,000	74,800 acfm	72,000
Hold Tank	5,220 gal	6,500	13,135 gal	12,000	26,220 gal	19,000	30,270 gal	21,500
Mixer		3,400		6,500		10,300		11,500
Circulation Pumps	1,000 gpm	17,000	2,596 gpm	20,000	5,134 gpm	23,000		24,000
		47,900		78,500		118,300		129,000
Solids Separation								
Clarifier	7.1 gpm	25,000	18 gpm	29,000	36.2 gpm	33,600	48.1 gpm	38,000
Clarifier Pumps - 2	7.1 gpm	6,400	18 gpm	7,800	36.2 gpm	8,800	48.1 gpm	9,200
Vacuum Filter	0.7 gpm	27,000	1.8 gpm	31,500	3.6 gpm	40,000	8.9 gpm	54,000
Clarifier Recycle Pumps	6 gpm	6,000	15 gpm	7,200	30 gpm	8,400	34.3 gpm	8,600
		64,400		75,500		90,800		109,800

APPENDIX C

UTILITY BOILER LIMESTONE FGD SYSTEM

PREMISES ON AN "INDUSTRIAL BASIS"

MATERIAL BALANCES
EQUIPMENT LISTS
CAPITAL INVESTMENT ESTIMATES
ANNUAL O&M COSTS
ANNUAL REVENUE REQUIREMENTS

APPENDIX C

As discussed in Section 2.1.2.3, TVA estimated the costs of utility boiler limestone FGD systems on an "industrial basis," i.e. with the following design scope differences from the standard TVA design scope described in Appendix A:

1. No stack gas reheat.
2. No spare absorber modules.
3. No on-site pond disposal. The waste solids are thickened and filtered to form a sludge which is hauled to off-site landfill disposal by an outside contractor.

This design is more typical of industrial boiler FGD system designs and is similar to the FGD system design scope used by Radian to develop industrial boiler FGD system costs.

The following information is included for each FGD system in this Appendix:

1. Plant heat rate
2. Flue gas characteristics
3. Coal analysis
4. Limestone analysis
5. Complete FGD system design scope
6. Material and energy balances
7. FGD system operating conditions
8. Sludge pond design criteria
9. FGD system process stream characterization
10. FGD system equipment list and costs
11. Equipment installation costs
12. Indirect investment costs
13. Annual O&M costs
14. Annual revenue requirements

Reheat & Spare Scrubber Investment

(10^3 $, 1980 $)

Boiler Capacity, MWe	100	250	500	1000
Reheat				
Equipment	735	1284	2140	4279
Installation Factor	2.25	2.25	2.21	2.16
Total Direct Investment	1652	2884	4729	9255
Indirect Investment Factor	1.979	1.978	1.975	1.975
Total Capital Investment	3269	5707	9340	18279
Spares				
Equipment	1988	2292	2423	4854
Installation Factor	2.25	2.25	2.21	2.16
Total Direct Investment	4468	5148	5354	10499
Indirect Investment Factor	1.979	1.978	1.975	1.975
Total Capital Investment	8843	10183	10575	20735
# Scrubbing Towers - Operating/Spares				
"Utility Basis"	1/1	2/1	4/1	8/2
"Industrial Basis"	1/0	2/0	4/0	8/0

Pond - determined by difference:

Utility Case - (Industrial Case + Reheat + Spares)

100 MW

```
  EXAMPLE INDUSTRIAL, LIMESTONE, NEW ECONOMIC PREMISES                        CASE 001

                         *** INPUTS ***

  BOILER CHARACTERISTICS
  ------ ---------------

  MEGAWATTS =   100.          INDUSTRIAL BASIS

  BOILER HEAT RATE =  9500. BTU/KWH

  EXCESS AIR =  39. PERCENT, INCLUDING LEAKAGE

  HOT GAS TEMPERATURE = 300. DEG F

  COAL ANALYSIS, WT % AS FIRED :

   C       H       O       N       S       CL     ASH    H2O
  66,70   3.80    5,60    1,30    3,36    0,10   15,10   4.00

  SULFUR OVERHEAD =  92,0 PERCENT

  ASH OVERHEAD =  80,0 PERCENT

  HEATING VALUE OF COAL = 11700, BTU/LB

                               EFFICIENCY,     EMISSION,
  FLYASH REMOVAL                   %           LBS/M BTU
  ------ -------              ------------    ---------

  UPSTREAM OF SCRUBBER            99,7            0,03

  WITHIN SCRUBBER                 50,0            0,02

  COST OF UPSTREAM FLYASH REMOVAL EXCLUDED


  ALKALI
  ------

  LIMESTONE :

          CACO3          =  97,15 WT % DRY BASIS
          SOLUBLE MGO =    0,0
          INERTS         =   2,85
          MOISTURE CONTENT =    5.00 LB H2O/100 LBS DRY LIMESTONE
          LIMESTONE HARDNESS WORK INDEX FACTOR = 10,00
          LIMESTONE DEGREE OF GRIND FACTOR =  1.35

  FLY ASH :

          SOLUBLE CAO =    0,0  WT %
          SOLUBLE MGO =    0,0
          INERTS        = 100,00


  RAW MATERIAL HANDLING AREA
  --- -------- -------- ----

  NUMBER OF REDUNDANT ALKALI PREPARATION UNITS =     0
```

100 MW

```
SCRUBBER SYSTEM VARIABLES
------- ------ ---------

NUMBER OF OPERATING SCRUBBING TRAINS =    1

NUMBER OF REDUNDANT SCRUBBING TRAINS =    0

NUMBER OF BEDS =    3

NUMBER OF GRIDS =    4

HEIGHT OF SPHERES PER BED =  5,0 INCHES

LIQUID-TO-GAS RATIO =  55, GAL/1000 ACF(SATD)

SCRUBBER GAS VELOCITY = 12,5 FT/SEC

INDUCED DRAFT SCRUBBER FAN OPTION

SCRUBBER PRESSURE = 14,7 PSIA

STOICHIOMETRY =  1,25 MOLE CACO3 ADDED AS LIMESTONE
                      PER MOLE (SO2+2HCL) ABSORBED

SO2 REMOVAL =  90, PERCENT

ENTRAINMENT LEVEL = 0,10 WT %

EHT RESIDENCE TIME =  12,0 MIN

SO2 OXIDIZED IN SYSTEM =  30,0 PERCENT

SOLIDS IN RECIRCULATED SLURRY =  15,0 WT %


SOLIDS DISPOSAL SYSTEM
------ -------- ------

COST OF LAND =  5000,00 DOLLARS/ACRE

SOLIDS IN SYSTEM SLUDGE DISCHARGE =  50,0 WT %

SOLIDS IN CLARIFIER DISCHARGE = 35,0 WT %

CLARIFIER SOLIDS SETTLING RATE = 0,20 FT/HR

SOLIDS IN FILTER CAKE = 50,0 WT %

FILTRATION RATE = 1,20 TONS DRY SOLIDS/FT2 DAY


NO REHEATERS
-- ---------
```

100 MW

```
EXAMPLE INDUSTRIAL, LIMESTONE, NEW ECONOMIC PREMISES                     CASE 001

                     *** OUTPUTS ***

HOT GAS TO SCRUBBER
--- --- -- --------

         MOLE PERCENT     LB-MOLE/HR     LB/HR

CO2         12.338        0.4509E+04     0.1985E+06
HCL          0.006        0.2290E+01     0.8351E+02
SO2          0.214        0.7829E+02     0.5015E+04
O2           5.560        0.2032E+04     0.6502E+05
N2          75.227        0.2749E+05     0.7704E+06
H2O          6.654        0.2432E+04     0.4381E+05

SO2 CONCENTRATION IN SCRUBBER INLET GAS = 2142. PPM
                                        = 5.28 LBS / MILLION BTU

FLYASH EMISSION =  0.03 LBS/MILLION BTU
                =  0.015 GRAINS/SCF (WET)  OR     29. LB/HR

       SOLUBLE CAO IN FLY ASH =     0. LB/HR
       SOLUBLE MGO IN FLY ASH =     0.

HOT GAS FLOW RATE =  .2309E+06 SCFM (60 DEG F, 14.7 PSIA)
                  =  .3374E+06 ACFM (300. DEG F, 14.7 PSIA)

CORRESPONDING COAL FIRING RATE =  .8120E+05 LB/HR

HOT GAS HUMIDITY =  0.042 LB H2O/LB DRY GAS

WET BULB TEMPERATURE = 124. DEG F


WET GAS FROM SCRUBBER
--- --- ---- --------

         MOLE PERCENT     LB-MOLE/HR     LB/HR

CO2         11.716        0.4582E+04     0.2017E+06
HCL          0.000        0.1145E+00     0.4175E+01
SO2          0.020        0.7829E+01     0.5015E+03
O2           5.169        0.2021E+04     0.6469E+05
N2          70.300        0.2749E+05     0.7704E+06
H2O         12.795        0.5004E+04     0.9015E+05

SO2 CONCENTRATION IN SCRUBBER OUTLET GAS =  200. PPM

FLYASH EMISSION =  0.02 LBS/MILLION BTU
                =  0.007 GRAINS/SCF (WET)  OR     15. LB/HR

TOTAL WATER PICKUP =   95.  GPM
          INCLUDING    2.3 GPM ENTRAINMENT

WET GAS FLOW RATE =  .2470E+06 SCFM (60 DEG F, 14.7 PSIA)
                  =  .2775E+06 ACFM (124. DEG F, 14.7 PSIA)

WET GAS SATURATION HUMIDITY =  0.087 LB H2O/LB DRY GAS
```

100 MW

```
FLUE GAS TO STACK
---- --- -- -----

         MOLE PERCENT     LB-MOLE/HR      LB/HR

CO2         11.697        0.4582E+04      0.2017E+06
HCL          0.000        0.1145E+00      0.4175E+01
SO2          0.020        0.7829E+01      0.5015E+03
O2           5.160        0.2021E+04      0.6469E+05
N2          70.188        0.2749E+05      0.7704E+06
H2O         12.934        0.5067E+04      0.9128E+05

SPECIFIED  SO2 REMOVAL EFFICIENCY =  90.0 %

CALCULATED SO2 EMISSION =   0.53 POUNDS PER MILLION BTU

CALCULATED SO2 CONCENTRATION IN STACK GAS =     200. PPM

FLYASH EMISSION =  0.02 LBS/MILLION BTU
                =  0.007 GRAINS/SCF (WET)  OR     15. LB/HR

STACK GAS FLOW RATE =  .2474E+06 SCFM (60 DEG F, 14.7 PSIA)
                    =  .2819E+06 ACFM (132. DEG F, 14.7 PSIA)
```

100 MW

```
WATER BALANCE INPUTS
----- ------- ------

  RAINFALL(IN/YEAR)                 50.
  POND SEEPAGE(CM/SEC)*10**8        50.
  POND EVAPORATION(IN/YEAR)         32.


WATER BALANCE OUTPUTS
----- ------- -------

WATER AVAILABLE

  RAINFALL                           0. GPM              109. LB/HR
  ALKALI                             1. GPM              461. LB/HR
      TOTAL                          1. GPM              569. LB/HR


WATER REQUIRED

  HUMIDIFICATION                    93. GPM            46339. LB/HR
  ENTRAINMENT                        2. GPM             1126. LB/HR
  DISPOSAL WATER                    24. GPM            11911. LB/HR
  HYDRATION WATER                    2. GPM             1201. LB/HR
  CLARIFIER EVAPORATION              4. GPM             2097. LB/HR
  POND EVAPORATION                   0. GPM                0. LB/HR
  SEEPAGE                            0. GPM                0. LB/HR

  TOTAL WATER REQUIRED             125. GPM            62674. LB/HR

NET WATER REQUIRED                 124. GPM            62104. LB/HR
```

100 MW

```
SCRUBBER SYSTEM
-------- ------

TOTAL NUMBER OF SCRUBBING TRAINS (OPERATING+REDUNDANT) =  1
SO2 REMOVAL =  90.0 PERCENT
PARTICULATE REMOVAL IN SCRUBBER SYSTEM =  50.0 PERCENT
TCA PRESSURE DROP ACROSS  3 BEDS =  6.6 IN. H2O
TOTAL SYSTEM PRESSURE DROP = 13.9 IN. H2O
OVERRIDE TOTAL SYSTEM PRESSURE DROP = 20.0 IN. H2O
SPECIFIED   LIQUID-TO-GAS-RATIO    =  55. GAL/1000 ACF(SATD)
LIMESTONE ADDITION = 0.9214E+04 LB/HR DRY LIMESTONE
SPECIFIED  LIMESTONE STOICHIOMETRY  =  1.25 MOLE CACO3 ADDED AS LIMESTONE
                                          PER MOLE (SO2+2HCL) ABSORBED
SOLUBLE CAO FROM FLY ASH =  0.0  MOLE PER MOLE (SO2+2HCL) ABSORBED
TOTAL SOLUBLE MGO         =  0.0  MOLE PER MOLE (SO2+2HCL) ABSORBED
TOTAL STOICHIOMETRY       =  1.25 MOLE SOLUBLE (CA+MG)
                                  PER MOLE (SO2+2HCL) ABSORBED
SCRUBBER INLET LIQUOR PH =  5.65
MAKE UP WATER =  124. GPM
CROSS-SECTIONAL AREA PER SCRUBBER =   370. SQ FT
```

100 MW

```
SOLIDS DISPOSAL SYSTEM
------ -------- ------

TOTAL CLARIFIER(S) CROSS-SECTIONAL AREA =   3664. SQ FT

SYSTEM SLUDGE DISCHARGE
------ ------ ---------
                                             SOLID    LIQUID
                                             COMP,    COMP,
SPECIES          LB-MOLE/HR     LB/HR        WT %     PPM

CASO3 .1/2 H2O   0.4932E+02     0.6367E+04   52.84
CASO4 .2H2O      0.2101E+02     0.3616E+04   30.01
CACO3            0.1788E+02     0.1790E+04   14.86
INSOLUBLES       ----------     0.2773E+03    2.30
H2O              0.6611E+03     0.1191E+05
CA++             0.1244E+01     0.4985E+02              4136.
MG++             0.0            0.0                        0.
SO3--            0.1898E-01     0.1519E+01               126.
SO4--            0.1314E+00     0.1262E+02              1047.
CL-              0.2176E+01     0.7714E+02              6401.


TOTAL DISCHARGE FLOW RATE = 0.2410E+05 LB/HR
                          =    33.     GPM

TOTAL DISSOLVED SOLIDS IN DISCHARGE LIQUID =  11697. PPM

DISCHARGE LIQUID PH =  7.28
```

100 MW

```
SCRUBBER SLURRY BLEED
-------- ------ -----

SPECIES            LB-MOLE/HR    LB/HR

CASO3 .1/2 H2O     0.4932E+02    0.6367E+04
CASO4 .2H2O        0.2101E+02    0.3616E+04
CACO3              0.1788E+02    0.1790E+04
INSOLUBLES         ----------    0.2773E+03
H2O                0.3746E+04    0.6749E+05
CA++               0.7047E+01    0.2825E+03
MG++               0.0           0.0
SO3--              0.1075E+00    0.8609E+01
SO4--              0.7444E+00    0.7151E+02
CL-                0.1233E+02    0.4371E+03
AD=                0.0           0.0

TOTAL FLOW RATE = 0.8034E+05 LB/HR
                =    146.     GPM


TOTAL SUPERNATE RETURN
----- --------- ------

SPECIES            LB-MOLE/HR    LB/HR

H2O                0.2976E+04    0.5362E+05
CA++               0.5599E+01    0.2244E+03
MG++               0.0           0.0
SO3--              0.8543E-01    0.6840E+01
SO4--              0.5914E+00    0.5681E+02
CL-                0.9795E+01    0.3472E+03
AD=                0.0           0.0

TOTAL FLOW RATE = 0.5425E+05 LB/HR
                =    109.     GPM


SUPERNATE TO WET BALL MILL
--------- -- --- ---- ----

SPECIES            LB-MOLE/HR    LB/HR

H2O                0.3370E+03    0.6071E+04
CA++               0.6339E+00    0.2541E+02
MG++               0.0           0.0
SO3--              0.9673E-02    0.7744E+00
SO4--              0.6696E-01    0.6432E+01
CL-                0.1109E+01    0.3932E+02
AD=                0.0           0.0

TOTAL FLOW RATE = 0.6143E+04 LB/HR
                =     12.     GPM
```

100 MW

```
LIMESTONE SLURRY FEED
--------- ------ ----

SPECIES              LB-MOLE/HR    LB/HR

CACO3                0.8943E+02    0.8952E+04
SOLUBLE MGO          0.0           0.0
INSOLUBLES           ----------    0.2626E+03
H2O                  0.3370E+03    0.6071E+04
CA++                 0.6339E+00    0.2541E+02
MG++                 0.0           0.0
SO3--                0.9673E-02    0.7744E+00
SO4--                0.6696E-01    0.6432E+01
CL-                  0.1109E+01    0.3932E+02
AD=                  0.0           0.0

TOTAL FLOW RATE = 0.1536E+05 LB/HR
                =     19.    GPM


SUPERNATE RETURN TO SCRUBBER OR EHT
--------- ------ -- -------- -- ---

SPECIES              LB-MOLE/HR    LB/HR

H2O                  0.2639E+04    0.4755E+05
CA++                 0.4965E+01    0.1990E+03
MG++                 0.0           0.0
SO3--                0.7576E-01    0.6065E+01
SO4--                0.5244E+00    0.5037E+02
CL-                  0.8686E+01    0.3079E+03
AD=                  0.0           0.0

TOTAL FLOW RATE = 0.4811E+05 LB/HR
                =     96.    GPM


RECYCLE SLURRY TO SCRUBBER
------- ------ -- --------

SPECIES              LB-MOLE/HR    LB/HR

CASO3 .1/2 H2O       0.5159E+04    0.6661E+06
CASO4 .2H2O          0.2198E+04    0.3793E+06
CACO3                0.1871E+04    0.1873E+06
INSOLUBLES           ----------    0.2901E+05
H2O                  0.3919E+06    0.7060E+07
CA++                 0.7372E+03    0.2955E+05
MG++                 0.0           0.0
SO3--                0.1125E+02    0.9006E+03
SO4--                0.7787E+02    0.7480E+04
CL-                  0.1290E+04    0.4572E+05
AD=                  0.0           0.0

TOTAL FLOW RATE = 0.8404E+07 LB/HR
                =  15264.    GPM
```

```
FLUE GAS COOLING SLURRY
---- --- ------- ------

SPECIES              LB-MOLE/HR    LB/HR

CASO3 .1/2 H2O       0.3752E+03    0.4844E+05
CASO4 .2H2O          0.1599E+03    0.2751E+05
CACO3                0.1361E+03    0.1362E+05
INSOLUBLES           ----------    0.2110E+04
H2O                  0.2850E+05    0.5135E+06
CA++                 0.5361E+02    0.2149E+04
MG++                 0.0           0.0
SO3--                0.8181E+00    0.6550E+02
SO4--                0.5663E+01    0.5440E+03
CL-                  0.9381E+02    0.3325E+04
AD=                  0.0           0.0

TOTAL FLOW RATE = 0.6112E+06 LB/HR
                =   1110.    GPM


CLARIFIER UNDERFLOW SLURRY
--------- --------- ------

SPECIES              LB-MOLE/HR    LB/HR

CASO3 .1/2 H2O       0.4932E+02    0.6367E+04
CASO4 .2H2O          0.2101E+02    0.3616E+04
CACO3                0.1788E+02    0.1790E+04
INSOLUBLES           ----------    0.2773E+03
H2O                  0.1228E+04    0.2212E+05
CA++                 0.2310E+01    0.9257E+02
MG++                 0.0           0.0
SO3--                0.3524E-01    0.2822E+01
SO4--                0.2440E+00    0.2344E+02
CL-                  0.4041E+01    0.1433E+03
AD=                  0.0           0.0

TOTAL FLOW RATE = 0.3443E+05 LB/HR
                =      54.   GPM


SUPERNATE FROM CLARIFIER
--------- ---- ---------

SPECIES              LB-MOLE/HR    LB/HR

CASO3 .1/2 H2O       0.0           0.0
CASO4 .2H2O          0.0           0.0
CACO3                0.0           0.0
INSOLUBLES           ----------    0.0
H2O                  0.2409E+04    0.4341E+05
CA++                 0.4533E+01    0.1817E+03
MG++                 0.0           0.0
SO3--                0.6916E-01    0.5537E+01
SO4--                0.4788E+00    0.4599E+02
CL-                  0.7930E+01    0.2811E+03
AD=                  0.0           0.0

TOTAL FLOW RATE = 0.4392E+05 LB/HR
```

```
                          =     88.    GPM

     FILTER CAKE SLURRY
     ------ ---- ------
     SPECIES              LB-MOLE/HR    LB/HR

     CASO3 .1/2 H2O       0.4932E+02    0.6367E+04
     CASO4 .2H2O          0.2101E+02    0.3616E+04
     CACO3                0.1788E+02    0.1790E+04
     INSOLUBLES           ----------    0.2773E+03
     H2O                  0.6611E+03    0.1191E+05
     CA++                 0.1244E+01    0.4985E+02
     MG++                 0.0           0.0
     SO3--                0.1898E-01    0.1519E+01
     SO4--                0.1314E+00    0.1262E+02
     CL-                  0.2176E+01    0.7714E+02
     AD=                  0.0           0.0

     TOTAL FLOW RATE = 0.2410E+05 LB/HR
                     =     33.    GPM

     FILTRATE FRUM FILTER
     -------- ---- ------
     SPECIES              LB-MULE/HR    LB/HR

     CASO3 .1/2 H2O       0.0           0.0
     CASO4 .2H2O          0.0           0.0
     CACO3                0.0           0.0
     INSOLUBLES           ----------    0.0
     H2O                  0.5667E+03    0.1021E+05
     CA++                 0.1066E+01    0.4272E+02
     MG++                 0.0           0.0
     SO3--                0.1627E-01    0.1302E+01
     SO4--                0.1126E+00    0.1082E+02
     CL-                  0.1865E+01    0.6612E+02
     AD=                  0.0           0.0

     TOTAL FLOW RATE = 0.1033E+05 LB/HR
                     =     21.    GPM
```

EXAMPLE INDUSTRIAL, LIMESTONE, NEW ECONOMIC PREMISES CASE 001

PARTICULATE REMOVAL INVESTMENT AND OPERATING COST

WPSUL CONTENT (%):	3.36
ASH CONTENT (%):	15.10
BTU RATING:	11700
BOILER TYPE:	DRY PULVERIZED COAL
NO. OF SCRUBBERS:	1
SCRUBBER VELOCITY (FT/M):	750.0
PLANT SIZE (MW):	100
OPERATING HRS/YR:	5256
PUMPING RATE (GAL/1000 ACF):	20.00
SCA RATIO: (ACTUAL SQ.FT./CALC. SQ.FT.)	1.300

PARTICULATE EMISSION REGULATION (LB ASH/MILLION BTU):	0.03
FLUE GAS TEMPERATURE (COLD) (F):	300.0
FLUE GAS TEMPERATURE (HOT) (F):	700.0
COST OF ELECTRICITY ($/KWHR):	0.03
COST OF STEAM ($/THOUSAND LB):	2.00
FIRST YEAR CAPITAL CHARGE FACTOR:	0.180
BAGHOUSE RATIO (OPER. SQ.FT./ACTUAL SQ.FT.):	0.80
BAG COST ($/SQ.FT.):	0.70
BAG LIFE(YEARS):	3.00
FLUE GAS REHEAT TEMPERATURE (F):	132.
CHEMICAL ENGINEERING PLANT INDEX:	265.0

	ELECTROSTATIC PRECIPITATORS			
	COLD	HOT	BAGHOUSE FABRIC FILTERS	SCRUBBERS
REQUIRED REMOVAL EFFICIENCY (%):	99.70	99.70	99.70	99.70
DRIFT VELOCITY (FT/M):	27.19	20.00		
SPECIFIC COLLECTION AREA (SQ.FT./ACFM):	277.74	377.39		
COLLECTION AREA (SQ.FT.):	93715.4	194462.1	173226.8	
TOTAL CORONA POWER (KW):	132.7	202.6		
AUXILIARY POWER (KW):	68.4	153.6	168.9	
FAN POWER (KW):	52.8	80.6	264.0	3208.0
PUMP POWER (KW):				653.6
TOTAL POWER (KW):	253.9	436.8	432.9	3861.5
OPERATING AIR/CLOTH RATIO:			2.4	
INSTALLED AIR/CLOTH RATIO:			1.9	
REQUIRED PRESSURE DROP (INCHES):	1.0	1.0	5.0	60.8
DIAMETER (FEET):				27
REQUIRED REHEAT (BTU/HR):				1204911.0
STEAM SUPPLY/YR (THOUSAND LB):				7036.7
INSTALLED COST (1979 DOLLARS):	$ 1582453	$ 2921883	$ 4277191	$ 5917050
FIRST YEAR CAPITALIZED COST:	$ 285369	$ 526913	$ 771320	$ 1067041
ANNUAL POWER COST:	$ 38701	$ 66577	$ 65982	$ 588592
ANNUAL OPERATING AND MAINTENANCE COST (1979 DOLLARS):	$ 46137	$ 69233	$ 49387	$ 310499
REPLACEMENT COST (1979 DOLLARS):			$ 53026	
ANNUAL REHEAT COST:				$ 14073
TOTAL ANNUAL COST:	$ 370207	$ 662723	$ 939715	$ 1980205
ANNUALIZED COST OF POWER(MILLS/KWHR):	0.70	1.26	1.79	3.77

100 MW

RAW MATERIAL HANDLING AND PREPARATION

ITEM	DESCRIPTION	NO.	MATERIAL	LABOR	
MOBILE EQUIPMENT	BUCKET TRACTOR	1	65176.	0.	
RECLAIM HOPPER	7FT WIDE, 4.25FT HT, 2FT WIDE BOTTOM, CS	1	1035.	675.	
RECLAIM VIBRATING FEEDER	3.5HP	1	4687.	432.	
RECLAIM BELT CONVEYOR	100FT, 2HP	1	19618.	1188.	
RECLAIM INCLINE BELT CONVEYOR	193FT, 40HP	1	31661.	3024.	
RECLAIM PIT DUST COLLECTOR	POLYPROPYLENE BAG TYPE	1	6648.	2160.	
RECLAIM PIT SUMP PUMP	60GPM, 70FT HEAD, 5HP	1	2071.	648.	
RECLAIM BUCKET ELEVATOR	90FT HIGH, 75HP	1	49591.	5509.	
FEED BIN	13FT DIA, 21FT STRAIGHT SIDE HT, COVERED, CS	1	12270.	6643.	
BIN WEIGH FEEDER	14FT PULLEY CENTERS, 2HP	1	14169.	648.	
GYRATORY CRUSHERS	75HP	1	84904.	1782.	
BALL MILL DUST COLLECTORS	POLYPROPYLENE BAG TYPE 2200 CFM, 7.5HP	1	6648.	2160.	
BALL MILL	4.6TPH, 100.HP	1	137073.	16396.	x
MILLS PRODUCT TANK	5500 GAL 10FT DIA, 10FT HT, FLAKEGLASS LINED CS	1	3924.	3024.	
MILLS PRODUCT TANK AGITATOR	10HP	1	6539.	1512.	x
MILLS PRODUCT TANK SLURRY PUMP	19.GPM, 60FT HEAD, 1.HP, 1 OPERATING AND 1 SPARES	2	4530.	1512.	
SLURRY FEED TANK	10237.GAL, 12.0FT DIA, 12.0FT HT, FLAKEGLASS-LINED CS	1	3370.	4287.	x
SLURRY FEED TANK AGITATOR	15.HP	1	10825.	838.	x
SLURRY FEED TANK PUMPS	19.GPM, 60 FT HEAD, 1.HP, 1 OPERATING AND 1 SPARE	2	4530.	1512.	x
			---------	---------	
TOTAL EQUIPMENT COST			491369.	53972.	

SCRUBBING

ITEM	DESCRIPTION	NO.	MATERIAL	LABOR
I.D. FANS	20.0IN H2O, WITH 1188. HP MOTOR AND DRIVE	1	746551.	10445.
SHELL			227480.	
RUBBER LINING			221274.	
MIST ELIMINATOR			42546.	
SLURRY HEADER AND NOZZLES			52337.	
GRIDS			91010.	
SPHERES			125535.	
TOTAL TCA SCRUBBER COSTS		1	760182.	35087.
SOOTBLOWERS		8	19182.	17282.
EFFLUENT HOLD TANK	201489.GAL, 32.5FT DIA, 32.5FT HT, FLAKEGLASS-LINED CS	1	44847.	35016.
EFFLUENT HOLD TANK AGITATOR	57.HP	1	39478.	4716.
COOLING SPRAY PUMPS	1110.GPM 100FT HEAD, 31.HP, 1 OPERATING AND 1 SPARE	2	13970.	4850.
ABSORBER RECYCLE PUMPS	7632.GPM, 100FT HEAD, 354.HP, 2 OPERATING AND 1 SPARE	3	219649.	16895.
MAKEUP WATER PUMPS	555.GPM, 200.FT HEAD, 47.HP, 1 OPERATING AND 1 SPARE	2	10903.	1189.
			----------	----------
TOTAL EQUIPMENT COST			1876758.	145478.

WASTE DISPOSAL

ITEM	DESCRIPTION	NO.	MATERIAL	LABOR
ABSORBER BLEED RECEIVING TANK	50320.GAL, 16.2FT DIA, 32.3FT HT, FLAKGLASS-LINED CS	1	17856.	14266.
ABSORBER BLEED TANK AGITATOR	33.HP	1	20219.	1603.
THICKENER FEED PUMP	146.GPM, 60FT HEAD, 4.HP, 1 OPERATING AND 1 SPARE	2	6813.	1998.
THICKENER	3664.SQ.FT., 68.FT DIA, 6.0TANK FT HT	1	102589.	101515.
THICKENER UNDERFLOW SLURRY PUMPS	54.GPM, 3.3FT HEAD, 0.HP , 1 OPERATING AND 1 SPARE	2	4187.	1512.
THICKENER OVERFLOW PUMPS	88.GPM, 75.0FT HEAD, 3.HP, 1 OPERATING AND 1 SPARE	2	7515.	819.
THICKENER OVERFLOW TANK	1450.GAL, 6.4FT DIA, 6.0FT HT	1	845.	558.
FILTER FEED TANK	892.GAL, 5.3FT DIA, 5.3FT HT, FLAKEGLASS-LINED CS	1	1056.	843.
FILTER FEED TANK AGITATOR	2.HP	1	865.	69.
FILTER FEED SLURRY PUMP	27.GPM, 30FT HEAD, 1.HP, 2 OPERATING AND 1 SPARE	3	6767.	2268.
FILTER	60.SQ FT FILTRATION AREA	2	94890.	26493.
FILTRATE PUMP (PER FILTER)	10.GPM, 20.0FT HEAD, 0.HP, 2 OPERATING AND 2 SPARE	4	13978.	1324.
FILTRATE SURGE TANK	341.GAL, 3.9FT DIA, 3.9FT HT	1	324.	214.
FILTRATE SURGE TANK PUMP	21.GPM, 65.0FT HEAD, 1.HP, 2 OPERATING AND 2SPARE	2	7142.	779.
			----------	----------
TOTAL EQUIPMENT COST			285046.	154461.

100 MW

LIMESTONE SLURRY PROCESS -- BASIS: 100 MW UNIT, 1981 STARTUP

PROJECTED CAPITAL INVESTMENT REQUIREMENTS - EXAMPLE INDUSTRIAL, LIMESTONE, NEW ECONOMIC PREMISES CASE 001

	INVESTMENT, THOUSANDS OF 1980 DOLLARS				DISTRIBUTION
	RAW MATERIAL HANDLING AND PREPARATION	SCRUBBING	WASTE DISPOSAL	TOTAL	PERCENT OF DIRECT INVESTMENT
EQUIPMENT					
MATERIAL	491.	1877.	285.	2653.	34.0
LABOR	54.	145.	154.	354.	4.5
PIPING					
MATERIAL	195.	504.	193.	892.	11.4
LABOR	79.	71.	86.	237.	3.0
DUCTWORK					
MATERIAL	0.	391.	0.	391.	5.0
LABOR	0.	287.	0.	287.	3.7
FOUNDATIONS					
MATERIAL	110.	26.	19.	155.	2.0
LABOR	301.	54.	39.	393.	5.0
POND CONSTRUCTION	0.	0.	0.	0.	0.0
STRUCTURAL					
MATERIAL	37.	52.	0.	89.	1.1
LABOR	35.	88.	0.	123.	1.6
ELECTRICAL					
MATERIAL	94.	138.	200.	432.	5.5
LABOR	176.	249.	578.	1003.	12.9
INSTRUMENTATION					
MATERIAL	41.	121.	40.	202.	2.6
LABOR	6.	20.	54.	79.	1.0
BUILDINGS					
MATERIAL	14.	0.	5.	19.	0.2
LABOR	15.	0.	5.	20.	0.3
SERVICES AND MISCELLANEOUS	106.	260.	107.	474.	6.1
SUBTOTAL DIRECT INVESTMENT	1753.	4283.	1767.	7803.	100.0
ENGINEERING DESIGN AND SUPERVISION	158.	385.	159.	702.	9.0
CONSTRUCTION EXPENSES	281.	685.	283.	1249.	16.0
CONTRACTOR FEES	88.	214.	88.	390.	5.0
CONTINGENCY	456.	1114.	459.	2029.	26.0
SUBTOTAL FIXED INVESTMENT	2736.	6681.	2756.	12173.	156.0
ALLOWANCE FOR STARTUP AND MODIFICATIONS	210.	514.	212.	936.	12.0
INTEREST DURING CONSTRUCTION	410.	1002.	413.	1826.	23.4
SUBTOTAL CAPITAL INVESTMENT	3356.	8197.	3381.	14936.	191.4
LAND	9.	1.	5.	15.	0.2
WORKING CAPITAL	110.	269.	111.	491.	6.3
TOTAL CAPITAL INVESTMENT	3475.	8467.	3497.	15441.	197.9

10/18

100 MW

```
LIMESTONE SLURRY PROCESS -- BASIS:  100 MW UNIT, 1981 STARTUP

PROJECTED REVENUE REQUIREMENTS - EXAMPLE INDUSTRIAL, LIMESTONE, NEW ECONOMIC PREMISES          CASE 001

                              DISPLAY SHEET FOR YEAR=    1         ø
                           ANNUAL OPERATION KW-HR/KW =  5256  -  0.6 cap factor

                      6.03 TONS PER HOUR                        DRY              SLUDGE
                          TOTAL CAPITAL INVESTMENT       14972000                  TOTAL
                                                                                   ANNUAL
                                            ANNUAL QUANTITY      UNIT COST,$       COST,$
                                            ---------------      -----------       ------
    DIRECT COSTS
    ------------
      RAW MATERIAL
      ------------
        LIMESTONE                              24.2 K TONS       8.00/TON            193700
                                                                                 ----------
           SUBTOTAL RAW MATERIAL                                                     193700

      CONVERSION COSTS
      ----------------
        OPERATING LABOR AND
          SUPERVISION                       27390.0 MAN-HR      12.50/MAN-HR         342400
        UTILITIES
          PROCESS WATER                     39190.0 K GAL        0.12/K GAL            4700
          ELECTRICITY                     9891580.0 KWH          0.029/KWH           286900
        MAINTENANCE
          LABOR AND MATERIAL (8%xDI)                                                 624300
        ANALYSES                             3220.0 HR          17.00/HR              54800
        Sludge Disposal                        63.4 K tons      15.00/HR             950810
           SUBTOTAL CONVERSION COSTS              (50% solids)                      2263910

           SUBTOTAL DIRECT COSTS                                                    2457610

    INDIRECT COSTS
    --------------
      OVERHEADS
        PLANT AND ADMINISTRATIVE (  60.0% OF CONVERSION COSTS LESS UTILITIES)        1183386
                                                                                 ----------
      FIRST YEAR OPERATING AND MAINTENANCE COSTS                                    3640996
      LEVELIZED CAPITAL CHARGES(  14.7% OF TOTAL CAPITAL INVESTMENT)                2269827
                                                                                 ----------
        FIRST YEAR ANNUAL COSTS                                                     5910823

---------------------------------------------------------------------------------------------------------
      HEAT RATE   9500. BTU/KWH    -    HEAT VALUE OF COAL    11700 BTU/LB    -    COAL RATE    213400 TONS/YR
```

250 MW

```
EXAMPLE INDUSTRIAL, LIMESTONE, NEW ECONOMIC PREMISES                      CASE 002

                    *** INPUTS ***

BOILER CHARACTERISTICS
------ ---------------
                         INDUSTRIAL BASIS
MEGAWATTS =   250.

BOILER HEAT RATE =  9500. BTU/KWH

EXCESS AIR =  39. PERCENT, INCLUDING LEAKAGE

HOT GAS TEMPERATURE = 300. DEG F

COAL ANALYSIS, WT % AS FIRED :

 C       H      O      N      S      CL     ASH    H2O
66,70   3,80   5,60   1,30   3,36   0,10   15,10   4,00

SULFUR OVERHEAD =  92,0 PERCENT

ASH OVERHEAD =  80,0 PERCENT

HEATING VALUE OF COAL = 11700. BTU/LB

                           EFFICIENCY,    EMISSION,
FLYASH REMOVAL                  %         LBS/M BTU
------ -------             -----------    ---------

UPSTREAM OF SCRUBBER          99,7           0,03

WITHIN SCRUBBER               50,0           0,02

COST OF UPSTREAM FLYASH REMOVAL EXCLUDED


ALKALI
------

LIMESTONE :

        CACO3          =  97,15 WT % DRY BASIS
        SOLUBLE MGO =    0,0
        INERTS         =   2,85
        MOISTURE CONTENT =    5,00 LB H2O/100 LBS DRY LIMESTONE
        LIMESTONE HARDNESS WORK INDEX FACTOR = 10,00
        LIMESTONE DEGREE OF GRIND FACTOR =  1,35

FLY ASH :

        SOLUBLE CAO =    0,0  WT %
        SOLUBLE MGO =    0,0
        INERTS         = 100,00


RAW MATERIAL HANDLING AREA
--- -------- -------- ----

NUMBER OF REDUNDANT ALKALI PREPARATION UNITS =     0
```

250 MW

```
SCRUBBER SYSTEM VARIABLES
-------- ------ ---------

NUMBER OF OPERATING SCRUBBING TRAINS =   2

NUMBER OF REDUNDANT SCRUBBING TRAINS =   0

NUMBER OF BEDS =   3

NUMBER OF GRIDS =   4

HEIGHT OF SPHERES PER BED =  5.0 INCHES

LIQUID-TO-GAS RATIO =  55. GAL/1000 ACF(SATD)

SCRUBBER GAS VELOCITY = 12.5 FT/SEC

INDUCED DRAFT SCRUBBER FAN OPTION

SCRUBBER PRESSURE = 14.7 PSIA

STOICHIOMETRY =  1.25 MOLE CACO3 ADDED AS LIMESTONE
                      PER MOLE (SO2+2HCL) ABSORBED

SO2 REMOVAL =  90. PERCENT

ENTRAINMENT LEVEL = 0.10 WT %

EMT RESIDENCE TIME =  12.0 MIN

SO2 OXIDIZED IN SYSTEM =  30.0 PERCENT

SOLIDS IN RECIRCULATED SLURRY =  15.0 WT %


SOLIDS DISPOSAL SYSTEM
------ -------- ------

COST OF LAND =  5000.00 DOLLARS/ACRE

SOLIDS IN SYSTEM SLUDGE DISCHARGE =  50.0 WT %

SOLIDS IN CLARIFIER DISCHARGE = 35.0 WT %

CLARIFIER SOLIDS SETTLING RATE = 0.20 FT/HR

SOLIDS IN FILTER CAKE = 50.0 WT %

FILTRATION RATE = 1.20 TONS DRY SOLIDS/FT2 DAY


NO REHEATERS
-- ---------
```

250 MW

```
EXAMPLE INDUSTRIAL, LIMESTONE, NEW ECONOMIC PREMISES                CASE 002

                    *** OUTPUTS ***

HOT GAS TO SCRUBBER
--- --- -- --------

          MOLE PERCENT      LB-MOLE/HR       LB/HR

CO2          12,338         0,1127E+05       0,4961E+06
HCL           0,006         0,5726E+01       0,2088E+03
SO2           0,214         0,1957E+03       0,1254E+05
O2            5,560         0,5080E+04       0,1626E+06
N2           75.227         0,6874E+05       0,1926E+07
H2O           6,654         0,6080E+04       0,1095E+06

SO2 CONCENTRATION IN SCRUBBER INLET GAS = 2142, PPM
                                        = 5,28 LBS / MILLION BTU

FLYASH EMISSION =  0,03 LBS/MILLION BTU
                =  0,015 GRAINS/SCF (WET)  OR     74, LB/HR

      SOLUBLE CAO IN FLY ASH =     0, LB/HR
      SOLUBLE MGO IN FLY ASH =     0,

HOT GAS FLOW RATE =  ,5772E+06 SCFM (60 DEG F, 14.7 PSIA)
                  =  ,8435E+06 ACFM (300, DEG F, 14.7 PSIA)

CORRESPONDING COAL FIRING RATE =  ,2030E+06 LB/HR

HOT GAS HUMIDITY =  0,042 LB H2O/LB DRY GAS

WET BULB TEMPERATURE = 124, DEG F


WET GAS FROM SCRUBBER
--- --- ---- --------

          MOLE PERCENT      LB-MOLE/HR       LB/HR

CO2          11,716         0,1146E+05       0,5042E+06
HCL           0,000         0,2863E+00       0,1044E+02
SO2           0,020         0,1957E+02       0,1254E+04
O2            5,169         0,5034E+04       0,1617E+06
N2           70.300         0,6874E+05       0,1926E+07
H2O          12.795         0,1251E+05       0,2254E+06

SO2 CONCENTRATION IN SCRUBBER OUTLET GAS =  200. PPM

FLYASH EMISSION =  0,02 LBS/MILLION BTU
                =  0,007 GRAINS/SCF (WET)  OR     37, LB/HR

TOTAL WATER PICKUP =  237,  GPM
          INCLUDING    5,6 GPM ENTRAINMENT

WET GAS FLOW RATE =  ,6176E+06 SCFM (60 DEG F, 14.7 PSIA)
                  =  ,6938E+06 ACFM (124, DEG F, 14.7 PSIA)

WET GAS SATURATION HUMIDITY =  0,087 LB H2O/LB DRY GAS
```

250 MW

FLUE GAS TO STACK

```
          MOLE PERCENT     LB-MOLE/HR      LB/HR

CO2          11.697        0.1146E+05     0.5042E+06
HCL           0.000        0.2863E+00     0.1044E+02
SO2           0.020        0.1957E+02     0.1254E+04
O2            5.160        0.5054E+04     0.1617E+06
N2           70.188        0.6874E+05     0.1926E+07
H2O          12.934        0.1267E+05     0.2282E+06

SPECIFIED  SO2 REMOVAL EFFICIENCY =  90.0 %

CALCULATED SO2 EMISSION =   0.53 POUNDS PER MILLION BTU

CALCULATED SO2 CONCENTRATION IN STACK GAS =     200. PPM

FLYASH EMISSION =  0.02 LBS/MILLION BTU
                =  0.007 GRAINS/SCF (WET)  OR     37. LB/HR

STACK GAS FLOW RATE =  .6186E+06 SCFM (60 DEG F, 14.7 PSIA)
                    =  .7047E+06 ACFM (132. DEG F, 14.7 PSIA)
```

250 MW

```
WATER BALANCE INPUTS
----- ------- ------

   RAINFALL(IN/YEAR)                       50.
   POND SEEPAGE(CM/SEC)*10**8              50.
   POND EVAPORATION(IN/YEAR)               32.


WATER BALANCE OUTPUTS
----- ------- -------

WATER AVAILABLE

   RAINFALL                                1. GPM                   271. LB/HR
   ALKALI                                  2. GPM                  1152. LB/HR
       TOTAL                               3. GPM                  1423. LB/HR


WATER REQUIRED

   HUMIDIFICATION                        232. GPM                115848. LB/HR
   ENTRAINMENT                             6. GPM                  2815. LB/HR
   DISPOSAL WATER                         60. GPM                 29776. LB/HR
   HYDRATION WATER                         6. GPM                  3004. LB/HR
   CLARIFIER EVAPORATION                  10. GPM                  5241. LB/HR
   POND EVAPORATION                        0. GPM                     0. LB/HR
   SEEPAGE                                 0. GPM                     0. LB/HR

   TOTAL WATER REQUIRED                  313. GPM                156684. LB/HR

NET WATER REQUIRED                       311. GPM                155261. LB/HR
```

250 MW

```
SCRUBBER SYSTEM
-------- ------

TOTAL NUMBER OF SCRUBBING TRAINS (OPERATING+REDUNDANT) =  2

SO2 REMOVAL =  90.0 PERCENT

PARTICULATE REMOVAL IN SCRUBBER SYSTEM =  50.0 PERCENT

TCA PRESSURE DROP ACROSS  3 BEDS =  8.6 IN. H2O

TOTAL SYSTEM PRESSURE DROP = 13.9 IN. H2O

OVERRIDE TOTAL SYSTEM PRESSURE DROP = 20.0 IN. H2O

SPECIFIED   LIQUID-TO-GAS-RATIO    =  55. GAL/1000 ACF(SATD)

LIMESTONE ADDITION = 0.2304E+05 LB/HR DRY LIMESTONE

SPECIFIED  LIMESTONE STOICHIOMETRY  =  1.25 MOLE CACO3 ADDED AS LIMESTONE
                                             PER MOLE (SO2+2HCL) ABSORBED

SOLUBLE CAO FROM FLY ASH =  0.0  MOLE PER MOLE (SO2+2HCL) ABSORBED

TOTAL SOLUBLE MGO        =  0.0  MOLE PER MOLE (SO2+2HCL) ABSORBED

TOTAL STOICHIOMETRY      =  1.25 MOLE SOLUBLE (CA+MG)
                                 PER MOLE (SO2+2HCL) ABSORBED

SCRUBBER INLET LIQUOR PH =  5.66

MAKE UP WATER =  311. GPM

CROSS-SECTIONAL AREA PER SCRUBBER =   463. SQ FT
```

```
SOLIDS DISPOSAL SYSTEM
------ -------- ------

TOTAL CLARIFIER(S) CROSS-SECTIONAL AREA =   9159. SQ FT

SYSTEM SLUDGE DISCHARGE
------ ------ ---------
                                                SOLID    LIQUID
                                                COMP,    COMP,
SPECIES            LB-MOLE/HR    LB/HR          WT %     PPM

CASO3 .1/2 H2O     0.1233E+03    0.1592E+05    52.84
CASO4 .2H2O        0.5253E+02    0.9041E+04    30.01
CACO3              0.4471E+02    0.4476E+04    14.86
INSOLUBLES         ----------    0.6933E+03     2.30
H2O                0.1653E+04    0.2978E+05
CA++               0.3109E+01    0.1246E+03              4136.
MG++               0.0           0.0                        0.
SO3--              0.4744E-01    0.3798E+01               126.
SO4--              0.3284E+00    0.3155E+02              1047.
CL-                0.5440E+01    0.1928E+03              6401.


TOTAL DISCHARGE FLOW RATE = 0.6026E+05 LB/HR
                          =    83.     GPM

TOTAL DISSOLVED SOLIDS IN DISCHARGE LIQUID =  11697. PPM

DISCHARGE LIQUID PH =  7.28
```

250 MW

```
SCRUBBER SLURRY BLEED
-------- ------ -----

SPECIES              LB-MOLE/HR    LB/HR

CASO3 .1/2 H2O       0.1233E+03    0.1592E+05
CASO4 .2H2O          0.5253E+02    0.9041E+04
CACO3                0.4471E+02    0.4476E+04
INSOLUBLES           ----------    0.6933E+03
H2O                  0.9366E+04    0.1667E+06
CA++                 0.1762E+02    0.7061E+03
MG++                 0.0           0.0
SO3--                0.2688E+00    0.2152E+02
SO4--                0.1861E+01    0.1788E+03
CL-                  0.3083E+02    0.1093E+04
AD=                  0.0           0.0

TOTAL FLOW RATE = 0.2009E+06 LB/HR
                =     365.    GPM


TOTAL SUPERNATE RETURN
----- --------- ------

SPECIES              LB-MOLE/HR    LB/HR

H2O                  0.7440E+04    0.1340E+06
CA++                 0.1400E+02    0.5610E+03
MG++                 0.0           0.0
SO3--                0.2136E+00    0.1710E+02
SO4--                0.1478E+01    0.1420E+03
CL-                  0.2449E+02    0.8681E+03
AD=                  0.0           0.0

TOTAL FLOW RATE = 0.1356E+06 LB/HR
                =     271.    GPM


SUPERNATE TO WET BALL MILL
--------- -- --- ---- ----

SPECIES              LB-MOLE/HR    LB/HR

H2O                  0.7876E+03    0.1419E+05
CA++                 0.1482E+01    0.5938E+02
MG++                 0.0           0.0
SO3--                0.2261E-01    0.1810E+01
SO4--                0.1565E+00    0.1503E+02
CL-                  0.2592E+01    0.9190E+02
AD=                  0.0           0.0

TOTAL FLOW RATE = 0.1436E+05 LB/HR
                =      29.    GPM
```

250 MW

```
LIMESTONE SLURRY FEED
--------- ------ ----

SPECIES              LB-MOLE/HR   LB/HR

CACO3                0.2236E+03   0.2238E+05
SOLUBLE MGO          0.0          0.0
INSOLUBLES           ----------   0.6565E+03
H2O                  0.8424E+03   0.1518E+05
CA++                 0.1482E+01   0.5938E+02
MG++                 0.0          0.0
SO3--                0.2261E-01   0.1810E+01
SO4--                0.1565E+00   0.1503E+02
CL-                  0.2592E+01   0.9190E+02
AD=                  0.0          0.0

TOTAL FLOW RATE = 0.3839E+05 LB/HR
                =      48.    GPM


SUPERNATE RETURN TO SCRUBBER OR EHT
--------- ------ -- -------- -- ---

SPECIES              LB-MOLE/HR   LB/HR

H2O                  0.6653E+04   0.1199E+06
CA++                 0.1251E+02   0.5016E+03
MG++                 0.0          0.0
SO3--                0.1910E+00   0.1529E+02
SO4--                0.1322E+01   0.1270E+03
CL-                  0.2190E+02   0.7762E+03
AD=                  0.0          0.0

TOTAL FLOW RATE = 0.1213E+06 LB/HR
                =     243.    GPM


RECYCLE SLURRY TO SCRUBBER
------- ------ -- --------

SPECIES              LB-MOLE/HR   LB/HR

CASO3 .1/2 H2O       0.1290E+05   0.1665E+07
CASO4 .2H2O          0.5495E+04   0.9457E+06
CACO3                0.4677E+04   0.4682E+06
INSOLUBLES           ----------   0.7252E+05
H2O                  0.9797E+06   0.1765E+08
CA++                 0.1843E+04   0.7387E+05
MG++                 0.0          0.0
SO3--                0.2812E+02   0.2251E+04
SO4--                0.1947E+03   0.1870E+05
CL-                  0.3225E+04   0.1143E+06
AD=                  0.0          0.0

TOTAL FLOW RATE = 0.2101E+08 LB/HR
                =  38161.     GPM
```

250 MW

```
FLUE GAS COOLING SLURRY
---- --- ------- ------

SPECIES            LB-MOLE/HR    LB/HR

CASO3 .1/2 H2O     0.9381E+03    0.1211E+06
CASO4 .2H2O        0.3997E+03    0.6878E+05
CACO3              0.3402E+03    0.3405E+05
INSOLUBLES         ----------    0.5274E+04
H2O                0.7125E+05    0.1284E+07
CA++               0.1340E+03    0.5372E+04
MG++               0.0           0.0
SO3--              0.2045E+01    0.1637E+03
SO4--              0.1416E+02    0.1360E+04
CL-                0.2345E+03    0.8313E+04
AD=                0.0           0.0

TOTAL FLOW RATE = 0.1528E+07 LB/HR
                =   2775.    GPM

CLARIFIER UNDERFLOW SLURRY
--------- --------- ------

SPECIES            LB-MOLE/HR    LB/HR

CASO3 .1/2 H2O     0.1233E+03    0.1592E+05
CASO4 .2H2O        0.5253E+02    0.9041E+04
CACO3              0.4471E+02    0.4476E+04
INSOLUBLES         ----------    0.6933E+03
H2O                0.3069E+04    0.5530E+05
CA++               0.5774E+01    0.2314E+03
MG++               0.0           0.0
SO3--              0.8811E-01    0.7054E+01
SO4--              0.6099E+00    0.5859E+02
CL-                0.1010E+02    0.3581E+03
AD=                0.0           0.0

TOTAL FLOW RATE = 0.8608E+05 LB/HR
                =    135.    GPM

SUPERNATE FROM CLARIFIER
--------- ---- ---------

SPECIES            LB-MOLE/HR    LB/HR

CASO3 .1/2 H2O     0.0           0.0
CASO4 .2H2O        0.0           0.0
CACO3              0.0           0.0
INSOLUBLES         ----------    0.0
H2O                0.6024E+04    0.1085E+06
CA++               0.1133E+02    0.4542E+03
MG++               0.0           0.0
SO3--              0.1729E+00    0.1384E+02
SO4--              0.1197E+01    0.1150E+03
CL-                0.1983E+02    0.7028E+03
AD=                0.0           0.0

TOTAL FLOW RATE = 0.1098E+06 LB/HR
```

250 MW

.220 GPM

```
FILTER CAKE SLURRY
------ ---- ------
SPECIES             LB-MOLE/HR    LB/HR

CASO3 .1/2 H2O      0,1233E+03    0,1592E+05
CASO4 .2H2O         0,5253E+02    0,9041E+04
CACO3               0,4471E+02    0,4476E+04
INSOLUBLES          ----------    0,6933E+03
H2O                 0,1653E+04    0,2978E+05
CA++                0,3109E+01    0,1246E+03
MG++                0,0           0,0
SO3--               0,4744E-01    0,3798E+01
SO4--               0,3284E+00    0,3155E+02
CL-                 0,5440E+01    0,1928E+03
AD=                 0,0           0,0

TOTAL FLOW RATE = 0,6026E+05 LB/HR
                =      83.    GPM


FILTRATE FROM FILTER
-------- ---- ------
SPECIES             LB-MOLE/HR    LB/HR

CASO3 .1/2 H2O      0,0           0,0
CASU4 .2H2O         0,0           0,0
CACO3               0,0           0,0
INSOLUBLES          ----------    0,0
H2O                 0,1417E+04    0,2552E+05
CA++                0,2665E+01    0,1068E+03
MG++                0,0           0,0
SO3--               0,4067E-01    0,3256E+01
SO4--               0,2815E+00    0,2704E+02
CL-                 0,4663E+01    0,1653E+03
AD=                 0,0           0,0

TOTAL FLOW RATE = 0,2582E+05 LB/HR
                =      52.    GPM
```

250 MW

```
          EXAMPLE INDUSTRIAL, LIMESTONE, NEW ECONOMIC PREMISES                    CASE 002

                         PARTICULATE REMOVAL INVESTMENT AND OPERATING COST
                                                  PARTICULATE EMISSION REGULATION (LB ASH/MILLION BTU):   0.03
WPSUL CONTENT (%):               3.36             FLUE GAS TEMPERATURE (COLD) (F):                       300.0
ASH CONTENT (%):                15.10             FLUE GAS TEMPERATURE (HOT) (F):                        700.0
BTU RATING:                     11700             COST OF ELECTRICITY ($/KWHR):                           0.03
BOILER TYPE:                    DRY PULVERIZED COAL COST OF STEAM ($/THOUSAND LB):                        2.00
NO. OF SCRUBBERS:                   2             FIRST YEAR CAPITAL CHARGE FACTOR:                       0.180
SCRUBBER VELOCITY (FT/M):       750.0             BAGHOUSE RATIO (OPER. SQ.FT./ACTUAL SQ.FT.):            0.80
PLANT SIZE (MW):                  250             BAG COST ($/SQ.FT.):                                    0.70
OPERATING HRS/YR:                5256             BAG LIFE(YEARS):                                        3.00
PUMPING RATE (GAL/1000 ACF):    20.00             FLUE GAS REHEAT TEMPERATURE (F):                        132.
SCA RATIO:                      1.300             CHEMICAL ENGINEERING PLANT INDEX:                      265.0
  (ACTUAL SQ.FT./CALC. SQ.FT.)



                          ELECTROSTATIC PRECIPITATORS

                                    COLD           HOT          BAGHOUSE FABRIC FILTERS       SCRUBBERS

REQUIRED REMOVAL EFFICIENCY (%):       99.70         99.70                   99.70              99.70
DRIFT VELOCITY (FT/M):                 27.19         20.00
SPECIFIC COLLECTION AREA (SQ.FT./ACFM): 277.74      377.59
COLLECTION AREA (SQ.FT.):           234288.6      486155.2                433067.2
TOTAL CORONA POWER (KW):               331.8         506.4
AUXILIARY POWER (KW):                  188.9         424.3                   309.8
FAN POWER (KW):                        132.0         201.5                   660.0             8020.0
PUMP POWER (KW):                                                                               1633.9
TOTAL POWER (KW):                      652.7        1132.2                   969.6             9653.9
OPERATING AIR/CLOTH RATIO:                                                     2.4
INSTALLED AIR/CLOTH RATIO:                                                     1.9
REQUIRED PRESSURE DROP (INCHES):         1.0           1.0                     5.0               60.8
DIAMETER (FEET):                                                                                    30
REQUIRED REHEAT (BTU/HR):                                                                  3012280.0
STEAM SUPPLY/YR (THOUSAND LB):                                                               17591.7
INSTALLED COST (1979 DOLLARS):    $ 3556565     $ 6585005              $ 9162336         $ 12732165
FIRST YEAR CAPITALIZED COST:      $  641367     $ 1187495              $ 1652274         $  2296033
ANNUAL POWER COST:                $   99484     $  172580              $  147825         $  1471479
ANNUAL OPERATING AND
 MAINTENANCE COST (1979 DOLLARS): $   76790     $  115231              $   57651         $   668123
REPLACEMENT COST (1979 DOLLARS):                                       $  132564
ANNUAL REHEAT COST:                                                                      $    35183



TOTAL ANNUAL COST:                $  817641     $ 1475306              $ 1990314         $  4470818
ANNUALIZED COST OF POWER(MILLS/KWHR):  0.62          1.12                    1.51               3.40
```

RAW MATERIAL HANDLING AND PREPARATION

ITEM	DESCRIPTION	NO.	MATERIAL	LABOR
MOBILE EQUIPMENT	BUCKET TRACTOR	1	65176.	0.
RECLAIM HOPPER	7FT WIDE, 4.25FT HT, 2FT WIDE BOTTOM, CS	1	1035.	675.
RECLAIM VIBRATING FEEDER	3.5HP	1	4687.	432.
RECLAIM BELT CONVEYOR	100FT, 2HP	1	19618.	1188.
RECLAIM INCLINE BELT CONVEYOR	193FT, 40HP	1	51661.	3024.
RECLAIM PIT DUST COLLECTOR	POLYPROPYLENE BAG TYPE	1	6648.	2160.
RECLAIM PIT SUMP PUMP	60GPM, 70FT HEAD, 5HP	1	2071.	648.
RECLAIM BUCKET ELEVATOR	90FT HIGH, 75HP	1	49591.	5509.
FEED BIN	13FT DIA, 21FT STRAIGHT SIDE HT, COVERED, CS	1	12370.	6643.
BIN WEIGH FEEDER	14FT PULLEY CENTERS, 2HP	1	14169.	648.
GYRATORY CRUSHERS	75HP	1	84904.	1782.
BALL MILL DUST COLLECTORS	POLYPROPYLENE BAG TYPE 2200 CFM, 7.5HP	1	6648.	2160.
BALL MILL	11.5TPH, 155.HP	1	162639.	18645.
MILLS PRODUCT TANK	5500 GAL 10FT DIA, 10FT HT, FLAKEGLASS LINED CS	1	3924.	3024.
MILLS PRODUCT TANK AGITATOR	10HP	1	6539.	1512.
MILLS PRODUCT TANK SLURRY PUMP	48.GPM, 60FT HEAD, 2.HP, 1 OPERATING AND 1 SPARES	2	4830.	1512.
SLURRY FEED TANK	25592.GAL, 16.3FT DIA, 16.3FT HT, FLAKEGLASS-LINED CS	1	9891.	7896.
SLURRY FEED TANK AGITATOR	28.HP	1	20701.	1641.
SLURRY FEED TANK PUMPS	24.GPM, 60 FT HEAD, 1.HP, 2 OPERATING AND 1 SPARE	3	6892.	2268.
			----------	----------
TOTAL EQUIPMENT COST			533994.	61368.

250 MW

SCRUBBING

ITEM	DESCRIPTION	NO.	MATERIAL	LABOR
I.D. FANS	20.0IN H2O, WITH 1482. HP MOTOR AND DRIVE	2	1698593.	23705.
SHELL			525383.	
RUBBER LINING			517850.	
MIST ELIMINATOR			107209.	
SLURRY HEADER AND NOZZLES			130762.	
GRIDS			232442.	
SPHERES			316993.	
TOTAL TCA SCRUBBER COSTS		2	1830636.	128125.
SOOTBLOWERS		16	38365.	34564.
EFFLUENT HOLD TANK	251861.GAL, 35.0FT DIA, 35.0FT HT, FLAKEGLASS-LINED CS	2	104080.	81262.
EFFLUENT HOLD TANK AGITATOR	66.HP	2	139302.	22088.
COOLING SPRAY PUMPS	1388.GPM 100FT HEAD, 64.HP, 2 OPERATING AND 2 SPARE	4	35919.	10694.
ABSORBER RECYCLE PUMPS	9540.GPM, 100FT HEAD, 442.HP, 4 OPERATING AND 2 SPARE	6	346500.	37252.
MAKEUP WATER PUMPS	1388.GPM, 200.FT HEAD, 117.HP, 1 OPERATING AND 1 SPARE	2	15981.	1742.
			----------	----------
TOTAL EQUIPMENT COST			4209373.	339432.

WASTE DISPOSAL

ITEM	DESCRIPTION	NO.	MATERIAL	LABOR
ABSORBER BLEED RECEIVING TANK	62898.GAL, 17.5FT DIA, 35.0FT HT, FLAKGLASS-LINED CS	1	20720.	16554.
ABSORBER BLEED TANK AGITATOR	38.HP	1	23676.	1877.
THICKENER FEED PUMP	365.GPM, 60FT HEAD, 10.HP, 1 OPERATING AND 1 SPARE	2	7870.	2982.
THICKENER	9159.SQ.FT.,108.FT DIA, 7.2TANK FT HT	1	195262.	196725.
THICKENER UNDERFLOW SLURRY PUMPS	135.GPM, 7.2FT HEAD, 1.HP , 1 OPERATING AND 1 SPARE	2	6087.	1932.
THICKENER OVERFLOW PUMPS	220.GPM, 75.0FT HEAD, 7.HP, 1 OPERATING AND 1 SPARE	2	7957.	867.
THICKENER OVERFLOW TANK	3625.GAL, 9.2FT DIA, 7.2FT HT	1	1519.	1004.
FILTER FEED TANK	2230.GAL, 7.2FT DIA, 7.2FT HT, FLAKEGLASS-LINED CS	1	1944.	1352.
FILTER FEED TANK AGITATOR	4.HP	1	2143.	170.
FILTER FEED SLURRY PUMP	68.GPM, 50FT HEAD, 2.HP, 2 OPERATING AND 1 SPARE	3	7207.	2268.
FILTER	151.SQ FT FILTRATION AREA	2	143467.	31670.
FILTRATE PUMP (PER FILTER)	26.GPM, 20.0FT HEAD, 0.HP, 2 OPERATING AND 2 SPARE	4	14281.	1557.
FILTRATE SURGE TANK	853.GAL, 5.3FT DIA, 5.3FT HT	1	598.	395.
FILTRATE SURGE TANK PUMP	52.GPM, 85.0FT HEAD, 2.HP, 2 OPERATING AND 2SPARE	2	7365.	803.
			---------	---------
TOTAL EQUIPMENT COST			440096.	260357.

250 MW

LIMESTONE SLURRY PROCESS -- BASIS: 250 MW UNIT, 1981 STARTUP

PROJECTED CAPITAL INVESTMENT REQUIREMENTS - EXAMPLE INDUSTRIAL, LIMESTONE, NEW ECONOMIC PREMISES CASE 002

	INVESTMENT, THOUSANDS OF 1980 DOLLARS				DISTRIBUTION
	RAW MATERIAL HANDLING AND PREPARATION	SCRUBBING	WASTE DISPOSAL	TOTAL	PERCENT OF DIRECT INVESTMENT
EQUIPMENT					
MATERIAL	534.	4209.	440.	5183.	37.8
LABOR	61.	339.	260.	661.	4.8
PIPING					
MATERIAL	211.	1170.	286.	1666.	12.2
LABOR	101.	160.	116.	377.	2.7
DUCTWORK					
MATERIAL	0.	954.	0.	954.	7.0
LABOR	0.	715.	0.	715.	5.2
FOUNDATIONS					
MATERIAL	113.	59.	21.	193.	1.4
LABOR	306.	123.	43.	472.	3.4
POND CONSTRUCTION	0.	0.	0.	0.	0.0
STRUCTURAL					
MATERIAL	37.	115.	0.	152.	1.1
LABOR	35.	194.	0.	229.	1.7
ELECTRICAL					
MATERIAL	98.	294.	205.	597.	4.4
LABOR	187.	557.	602.	1345.	9.8
INSTRUMENTATION					
MATERIAL	49.	240.	40.	329.	2.4
LABOR	7.	40.	54.	101.	0.7
BUILDINGS					
MATERIAL	18.	0.	13.	31.	0.2
LABOR	19.	0.	13.	32.	0.2
SERVICES AND MISCELLANEOUS	90.	467.	107.	664.	4.8
SUBTOTAL DIRECT INVESTMENT	1866.	9636.	2199.	13700.	100.0
ENGINEERING DESIGN AND SUPERVISION	168.	867.	198.	1233.	9.0
CONSTRUCTION EXPENSES	299.	1542.	352.	2192.	16.0
CONTRACTOR FEES	93.	482.	110.	685.	5.0
CONTINGENCY	485.	2505.	572.	3562.	26.0
SUBTOTAL FIXED INVESTMENT	2911.	15032.	3431.	21372.	156.0
ALLOWANCE FOR STARTUP AND MODIFICATIONS	224.	1156.	264.	1644.	12.0
INTEREST DURING CONSTRUCTION	437.	2255.	515.	3206.	23.4
SUBTOTAL CAPITAL INVESTMENT	3572.	18443.	4210.	26222.	191.4
LAND	9.	2.	8.	19.	0.1
WORKING CAPITAL	116.	599.	137.	852.	6.2
TOTAL CAPITAL INVESTMENT	3697.	19044.	4355.	27093.	197.8

250 MW

```
LIMESTONE SLURRY PROCESS -- BASIS:  250 MW UNIT, 1981 STARTUP

PROJECTED REVENUE REQUIREMENTS - EXAMPLE INDUSTRIAL, LIMESTONE, NEW ECONOMIC PREMISES                    CASE 002

                              DISPLAY SHEET FOR YEAR=    1
                            ANNUAL OPERATION KW-HR/KW =  5256

                    15.06 TONS PER HOUR                          DRY                  SLUDGE
                         TOTAL CAPITAL INVESTMENT       26270000                          TOTAL
                                                                                         ANNUAL
                                        ANNUAL QUANTITY         UNIT COST,$              COST,$
                                        ---------------         -----------              ------
      DIRECT COSTS
      ------------
        RAW MATERIAL
        ------------
          LIMESTONE                          60.5 K TONS        8.00/TON                 484300
                                                                                      ----------
             SUBTOTAL RAW MATERIAL                                                       484300

        CONVERSION COSTS
        ----------------
          OPERATING LABOR AND
            SUPERVISION                   34820.0 MAN-HR       12.50/MAN-HR              435200
          UTILITIES
            PROCESS WATER                 97970.0 K GAL         0.12/K GAL                11800
            ELECTRICITY                22503120.0 KWH           0.029/KWH                652600
          MAINTENANCE
            LABOR AND MATERIAL                                                          1096000
          ANALYSES                         3220.0 HR           17.00/HR                   54800
          Sludge Disposal                   158.3 " tons       15.00/HR                 2374661
             SUBTOTAL CONVERSION COSTS                                                  4625061

             SUBTOTAL DIRECT COSTS                                                      5109361

      INDIRECT COSTS
      --------------
        OVERHEADS
          PLANT AND ADMINISTRATIVE (  60.0% OF CONVERSION COSTS LESS UTILITIES)          2376397
                                                                                      ----------
        FIRST YEAR OPERATING AND MAINTENANCE COSTS                                      7485768
        LEVELIZED CAPITAL CHARGES( 14.7% OF TOTAL CAPITAL INVESTMENT)                    398261
                                                                                      ----------
           FIRST YEAR ANNUAL COSTS                                                     11468439



-----------------------------------------------------------------------------------------------------------
        HEAT RATE   9500, BTU/KWH     -     HEAT VALUE OF COAL     11700 BTU/LB     -     COAL RATE    533500 TONS/YR
```

500 MW

```
EXAMPLE INDUSTRIAL, LIMESTONE, NEW ECONOMIC PREMISES                   CASE 003

                     *** INPUTS ***

BOILER CHARACTERISTICS
------ ---------------

MEGAWATTS =   500.   INDUSTRIAL BASIS

BOILER HEAT RATE =  9500. BTU/KWH

EXCESS AIR =  39. PERCENT, INCLUDING LEAKAGE

HOT GAS TEMPERATURE = 300. DEG F

COAL ANALYSIS, WT % AS FIRED :

 C       H      O      N      S      CL    ASH    H2O
66.70   3.80   5.60   1.30   3.36   0.10  15.10   4.00

SULFUR OVERHEAD =  92.0 PERCENT

ASH OVERHEAD =  80.0 PERCENT

HEATING VALUE OF COAL = 11700. BTU/LB

                           EFFICIENCY,    EMISSION,
FLYASH REMOVAL                 %          LBS/M BTU
------ -------            -----------    ---------

UPSTREAM OF SCRUBBER          99.7           0.03

WITHIN SCRUBBER               50.0           0.02

COST OF UPSTREAM FLYASH REMOVAL EXCLUDED


ALKALI
------

LIMESTONE :

       CACO3         =  97.15 WT % DRY BASIS
       SOLUBLE MGO =    0.0
       INERTS        =   2.85
       MOISTURE CONTENT =   5.00 LB H2O/100 LBS DRY LIMESTONE
       LIMESTONE HARDNESS WORK INDEX FACTOR = 10.00
       LIMESTONE DEGREE OF GRIND FACTOR =  1.35

FLY ASH :

       SOLUBLE CAO =    0.0  WT %
       SOLUBLE MGO =    0.0
       INERTS       = 100.00


RAW MATERIAL HANDLING AREA
--- -------- -------- ----

NUMBER OF REDUNDANT ALKALI PREPARATION UNITS =    0
```

500 MW

```
SCRUBBER SYSTEM VARIABLES
-------- ------ ---------

NUMBER OF OPERATING SCRUBBING TRAINS =   4
NUMBER OF REDUNDANT SCRUBBING TRAINS =   0
NUMBER OF BEDS =   3
NUMBER OF GRIDS =   4
HEIGHT OF SPHERES PER BED =  5.0 INCHES
LIQUID-TO-GAS RATIO =  55. GAL/1000 ACF(SATD)
SCRUBBER GAS VELOCITY = 12.5 FT/SEC
INDUCED DRAFT SCRUBBER FAN OPTION
SCRUBBER PRESSURE = 14.7 PSIA
STOICHIOMETRY =  1.25 MOLE CACO3 ADDED AS LIMESTONE
                      PER MOLE (SO2+2HCL) ABSORBED
SO2 REMOVAL =  90. PERCENT
ENTRAINMENT LEVEL = 0.10 WT %
EHT RESIDENCE TIME =  12.0 MIN
SO2 OXIDIZED IN SYSTEM =  30.0 PERCENT
SOLIDS IN RECIRCULATED SLURRY =  15.0 WT %

SOLIDS DISPOSAL SYSTEM
------ -------- ------

COST OF LAND =  5000.00 DOLLARS/ACRE
SOLIDS IN SYSTEM SLUDGE DISCHARGE =  50.0 WT %
SOLIDS IN CLARIFIER DISCHARGE = 35.0 WT %
CLARIFIER SOLIDS SETTLING RATE = 0.20 FT/HR
SOLIDS IN FILTER CAKE = 50.0 WT %
FILTRATION RATE = 1.20 TONS DRY SOLIDS/FT2 DAY


NO REHEATERS
-- ---------
```

500 MW

```
EXAMPLE INDUSTRIAL, LIMESTONE, NEW ECONOMIC PREMISES                           CASE 003

                     *** OUTPUTS ***

HOT GAS TO SCRUBBER
--- --- -- --------

          MOLE PERCENT      LB-MOLE/HR       LB/HR

CO2          12.338         0.2255E+05      0.9923E+06
HCL           0.006         0.1145E+02      0.4175E+03
SO2           0.214         0.3914E+03      0.2508E+05
O2            5.560         0.1016E+05      0.3251E+06
N2           75.227         0.1375E+06      0.3852E+07
H2O           6.654         0.1216E+05      0.2191E+06

SO2 CONCENTRATION IN SCRUBBER INLET GAS = 2142. PPM
                                        = 5.28 LBS / MILLION BTU

FLYASH EMISSION =  0.03 LBS/MILLION BTU
                =  0.015 GRAINS/SCF (WET)  OR    147. LB/HR

       SOLUBLE CAO IN FLY ASH =     0. LB/HR
       SOLUBLE MGO IN FLY ASH =     0.

HOT GAS FLOW RATE =  .1154E+07 SCFM (60 DEG F, 14.7 PSIA)
                  =  .1687E+07 ACFM (300. DEG F, 14.7 PSIA)

CORRESPONDING COAL FIRING RATE =  .4060E+06 LB/HR

HOT GAS HUMIDITY =  0.042 LB H2O/LB DRY GAS

WET BULB TEMPERATURE = 124. DEG F


WET GAS FROM SCRUBBER
--- --- ---- --------

          MOLE PERCENT      LB-MOLE/HR       LB/HR

CO2          11.716         0.2291E+05      0.1008E+07
HCL           0.000         0.5726E+00      0.2088E+02
SO2           0.020         0.3914E+02      0.2508E+04
O2            5.169         0.1011E+05      0.3234E+06
N2           70.300         0.1375E+06      0.3852E+07
H2O          12.795         0.2502E+05      0.4508E+06

SO2 CONCENTRATION IN SCRUBBER OUTLET GAS =  200. PPM

FLYASH EMISSION =  0.02 LBS/MILLION BTU
                =  0.007 GRAINS/SCF (WET)  OR     74. LB/HR

TOTAL WATER PICKUP =  475.  GPM
          INCLUDING   11.3 GPM ENTRAINMENT

WET GAS FLOW RATE =  .1235E+07 SCFM (60 DEG F, 14.7 PSIA)
                  =  .1388E+07 ACFM (124. DEG F, 14.7 PSIA)

WET GAS SATURATION HUMIDITY =  0.087 LB H2O/LB DRY GAS
```

500 MW

FLUE GAS TO STACK

```
          MOLE PERCENT     LB-MOLE/HR     LB/HR

CO2          11.697        0.2291E+05     0.1008E+07
HCL           0.000        0.5726E+00     0.2088E+02
SO2           0.020        0.3914E+02     0.2508E+04
O2            5.160        0.1011E+05     0.3234E+06
N2           70.188        0.1375E+06     0.3852E+07
H2O          12.934        0.2533E+05     0.4564E+06

SPECIFIED  SO2 REMOVAL EFFICIENCY =  90.0 %

CALCULATED SO2 EMISSION =   0.53 POUNDS PER MILLION BTU

CALCULATED SO2 CONCENTRATION IN STACK GAS =     200. PPM

FLYASH EMISSION =  0.02 LBS/MILLION BTU
                =  0.007 GRAINS/SCF (WET)  OR     74. LB/HR

STACK GAS FLOW RATE =  .1237E+07 SCFM (60 DEG F, 14.7 PSIA)
                    =  .1409E+07 ACFM (132. DEG F, 14.7 PSIA)
```

500 MW

```
   WATER BALANCE INPUTS
   ----- ------- ------

     RAINFALL(IN/YEAR)                  50.
     POND SEEPAGE(CM/SEC)*10**8         50.
     POND EVAPORATION(IN/YEAR)          32.


   WATER BALANCE OUTPUTS
   ----- ------- -------

   WATER AVAILABLE

     RAINFALL                            1. GPM                 543. LB/HR
     ALKALI                              5. GPM                2304. LB/HR
         TOTAL                           6. GPM                2846. LB/HR

   WATER REQUIRED

     HUMIDIFICATION                    464. GPM              231695. LB/HR
     ENTRAINMENT                        11. GPM                5630. LB/HR
     DISPOSAL WATER                    119. GPM               59553. LB/HR
     HYDRATION WATER                    12. GPM                6007. LB/HR
     CLARIFIER EVAPORATION              21. GPM               10483. LB/HR
     POND EVAPORATION                    0. GPM                   0. LB/HR
     SEEPAGE                             0. GPM                   0. LB/HR

     TOTAL WATER REQUIRED              627. GPM              313368. LB/HR

   NET WATER REQUIRED                  621. GPM              310521. LB/HR
```

500 MW

```
SCRUBBER SYSTEM
-------- ------

TOTAL NUMBER OF SCRUBBING TRAINS (OPERATING+REDUNDANT) =  4

SO2 REMOVAL =  90.0 PERCENT

PARTICULATE REMOVAL IN SCRUBBER SYSTEM =  50.0 PERCENT

TCA PRESSURE DROP ACROSS  3 BEDS =  8.6 IN. H2O

TOTAL SYSTEM PRESSURE DROP = 13.9 IN. H2O

OVERRIDE TOTAL SYSTEM PRESSURE DROP = 20.0 IN. H2O

SPECIFIED   LIQUID-TO-GAS-RATIO     =  55. GAL/1000 ACF(SATD)

LIMESTONE ADDITION = 0.4607E+05 LB/HR DRY LIMESTONE

SPECIFIED  LIMESTONE STOICHIOMETRY  =  1.25 MOLE CACO3 ADDED AS LIMESTONE
                                           PER MOLE (SO2+2HCL) ABSORBED

SOLUBLE CAO FROM FLY ASH =  0.0  MOLE PER MOLE (SO2+2HCL) ABSORBED

TOTAL SOLUBLE MGO        =  0.0  MOLE PER MOLE (SO2+2HCL) ABSORBED

TOTAL STOICHIOMETRY      =  1.25 MOLE SOLUBLE (CA+MG)
                                 PER MOLE (SO2+2HCL) ABSORBED

SCRUBBER INLET LIQUOR PH =  5.66

MAKE UP WATER =  621. GPM

CROSS-SECTIONAL AREA PER SCRUBBER =   463. SQ FT
```

500 MW

```
SOLIDS DISPUSAL SYSTEM
------ -------- ------

TOTAL CLARIFIER(S) CROSS-SECTIONAL AREA =  18318, SQ FT

SYSTEM SLUDGE DISCHARGE
------ ------ ---------
                                                   SOLID   LIQUID
                                                   COMP,   COMP,
SPECIES          LB-MOLE/HR     LB/HR              WT %    PPM

CASO3 .1/2 H2O   0,2466E+03     0.3184E+05         52.84
CASO4 ,2H2O      0,1051E+03     0,1808E+05         30,01
CACO3            0,8942E+02     0,8951E+04         14.86
INSOLUBLES       ----------     0,1387E+04          2,30
H2O              0,3306E+04     0,5935E+05
CA++             0,6218E+01     0,2492E+03                   4136,
MG++             0,0            0,0                             0,
SO3--            0,9489E-01     0,7597E+01                    126,
SO4--            0,6568E+00     0,6309E+02                   1047,
CL-              0,1088E+02     0,3857E+03                   6401,


TOTAL DISCHARGE FLOW RATE = 0,1205E+06 LB/HR
                          =   167,     GPM

TOTAL DISSOLVED SOLIDS IN DISCHARGE LIQUID =  11697, PPM

DISCHARGE LIQUID PH =  7,28
```

500 MW

```
SCRUBBER SLURRY BLEED
-------- ------ -----

SPECIES              LB-MOLE/HR    LB/HR

CASO3 .1/2 H2O       0.2466E+03    0.3184E+05
CASO4 .2H2O          0.1051E+03    0.1808E+05
CACO3                0.8942E+02    0.8951E+04
INSOLUBLES           ----------    0.1387E+04
H2O                  0.1873E+05    0.3375E+06
CA++                 0.3524E+02    0.1412E+04
MG++                 0.0           0.0
SO3--                0.5377E+00    0.4305E+02
SO4--                0.3722E+01    0.3575E+03
CL-                  0.6165E+02    0.2186E+04
AD=                  0.0           0.0

TOTAL FLOW RATE = 0.4017E+06 LB/HR
                =    730.    GPM


TOTAL SUPERNATE RETURN
----- --------- ------

SPECIES              LB-MOLE/HR    LB/HR

H2O                  0.1488E+05    0.2681E+06
CA++                 0.2799E+02    0.1122E+04
MG++                 0.0           0.0
SO3--                0.4271E+00    0.3420E+02
SO4--                0.2957E+01    0.2840E+03
CL-                  0.4898E+02    0.1736E+04
AD=                  0.0           0.0

TOTAL FLOW RATE = 0.2713E+06 LB/HR
                =    543.    GPM


SUPERNATE TO WET BALL MILL
--------- -- --- ---- ----

SPECIES              LB-MOLE/HR    LB/HR

H2O                  0.1575E+04    0.2838E+05
CA++                 0.2963E+01    0.1188E+03
MG++                 0.0           0.0
SO3--                0.4522E-01    0.3620E+01
SO4--                0.3130E+00    0.3007E+02
CL-                  0.5184E+01    0.1838E+03
AD=                  0.0           0.0

TOTAL FLOW RATE = 0.2871E+05 LB/HR
                =     57.    GPM
```

500 MW

```
LIMESTONE SLURRY FEED
--------- ------ ----

SPECIES            LB-MOLE/HR   LB/HR

CACO3              0.4471E+03   0.4476E+05
SOLUBLE MGO        0.0          0.0
INSOLUBLES         ----------   0.1313E+04
H2O                0.1685E+04   0.3035E+05
CA++               0.2963E+01   0.1188E+03
MG++               0.0          0.0
SO3--              0.4522E-01   0.3620E+01
SO4--              0.3130E+00   0.3007E+02
CL-                0.5184E+01   0.1838E+03
AD=                0.0          0.0

TOTAL FLOW RATE = 0.7678E+05 LB/HR
                =     97.     GPM

SUPERNATE RETURN TO SCRUBBER OR EHT
--------- ------ -- -------- -- ---

SPECIES            LB-MOLE/HR   LB/HR

H2O                0.1331E+05   0.2397E+06
CA++               0.2503E+02   0.1003E+04
MG++               0.0          0.0
SO3--              0.3819E+00   0.3058E+02
SO4--              0.2644E+01   0.2540E+03
CL-                0.4379E+02   0.1552E+04
AD=                0.0          0.0

TOTAL FLOW RATE = 0.2425E+06 LB/HR
                =    485.     GPM

RECYCLE SLURRY TO SCRUBBER
------- ------ -- --------

SPECIES            LB-MOLE/HR   LB/HR

CASO3 .1/2 H2O     0.2580E+05   0.3330E+07
CASO4 .2H2O        0.1099E+05   0.1891E+07
CACO3              0.9354E+04   0.9364E+06
INSOLUBLES         ----------   0.1450E+06
H2O                0.1959E+07   0.3530E+08
CA++               0.3686E+04   0.1477E+06
MG++               0.0          0.0
SO3--              0.5625E+02   0.4503E+04
SO4--              0.3893E+03   0.3740E+05
CL-                0.6449E+04   0.2286E+06
AD=                0.0          0.0

TOTAL FLOW RATE = 0.4202E+08 LB/HR
                =  76321.     GPM
```

500 MW

```
FLUE GAS COOLING SLURRY
---- --- ------- ------

SPECIES              LB-MOLE/HR    LB/HR

CASO3 .1/2 H2O       0.1876E+04    0.2422E+06
CASO4 .2H2O          0.7993E+03    0.1376E+06
CACO3                0.6803E+03    0.6810E+05
INSOLUBLES           ----------    0.1055E+05
H2O                  0.1425E+06    0.2567E+07
CA++                 0.2681E+03    0.1074E+05
MG++                 0.0           0.0
SO3--                0.4091E+01    0.3275E+03
SO4--                0.2832E+02    0.2720E+04
CL-                  0.4690E+03    0.1663E+05
AD=                  0.0           0.0

TOTAL FLOW RATE = 0.3056E+07 LB/HR
                =    5551.    GPM

CLARIFIER UNDERFLOW SLURRY
--------- --------- ------

SPECIES              LB-MOLE/HR    LB/HR

CASO3 .1/2 H2O       0.2466E+03    0.3184E+05
CASO4 .2H2O          0.1051E+03    0.1808E+05
CACO3                0.8942E+02    0.8951E+04
INSOLUBLES           ----------    0.1387E+04
H2O                  0.6139E+04    0.1106E+06
CA++                 0.1155E+02    0.4629E+03
MG++                 0.0           0.0
SO3--                0.1762E+00    0.1411E+02
SO4--                0.1220E+01    0.1172E+03
CL-                  0.2021E+02    0.7163E+03
AD=                  0.0           0.0

TOTAL FLOW RATE = 0.1722E+06 LB/HR
                =     270.    GPM

SUPERNATE FROM CLARIFIER
--------- ---- ---------

SPECIES              LB-MOLE/HR    LB/HR

CASO3 .1/2 H2O       0.0           0.0
CASO4 .2H2O          0.0           0.0
CACO3                0.0           0.0
INSOLUBLES           ----------    0.0
H2O                  0.1205E+05    0.2170E+06
CA++                 0.2266E+02    0.9083E+03
MG++                 0.0           0.0
SO3--                0.3458E+00    0.2769E+02
SO4--                0.2394E+01    0.2300E+03
CL-                  0.3965E+02    0.1406E+04
AD=                  0.0           0.0

TOTAL FLOW RATE = 0.2196E+06 LB/HR
```

500 MW

```
                     =    439.    GPM

    FILTER CAKE SLURRY
    ------ ---- ------
    SPECIES             LB-MOLE/HR   LB/HR

    CASO3 .1/2 H2O      0,2466E+03   0,3184E+05
    CASO4 .2H2O         0,1051E+03   0,1808E+05
    CACO3               0,8942E+02   0,8951E+04
    INSOLUBLES          ----------   0,1387E+04
    H2O                 0,3306E+04   0,5955E+05
    CA++                0,6218E+01   0,2492E+03
    MG++                0,0          0,0
    SO3--               0,9489E-01   0,7597E+01
    SO4--               0,6568E+00   0,6309E+02
    CL-                 0,1088E+02   0,3857E+03
    AD=                 0,0          0,0

    TOTAL FLOW RATE = 0,1205E+06 LB/HR
                    =    167.    GPM


    FILTRATE FROM FILTER
    -------- ---- ------
    SPECIES             LB-MOLE/HR   LB/HR

    CASO3 .1/2 H2O      0,0          0,0
    CASO4 .2H2O         0,0          0,0
    CACO3               0,0          0,0
    INSOLUBLES          ----------   0,0
    H2O                 0,2833E+04   0,5105E+05
    CA++                0,5330E+01   0,2136E+03
    MG++                0,0          0,0
    SO3--               0,8133E-01   0,6511E+01
    SO4--               0,5630E+00   0,5408E+02
    CL-                 0,9325E+01   0,3306E+03
    AD=                 0,0          0,0

    TOTAL FLOW RATE = 0,5165E+05 LB/HR
                    =    103.    GPM
```

500 MW

EXAMPLE INDUSTRIAL, LIMESTONE, NEW ECONOMIC PREMISES CASE 003

PARTICULATE REMOVAL INVESTMENT AND OPERATING COST

		PARTICULATE EMISSION REGULATION (LB ASH/MILLION BTU):	0.03
WPSUL CONTENT (%):	3.36	FLUE GAS TEMPERATURE (COLD) (F):	300.0
ASH CONTENT (%):	15.10	FLUE GAS TEMPERATURE (HOT) (F):	700.0
BTU RATING:	11700	COST OF ELECTRICITY ($/KWHR):	0.03
BOILER TYPE:	DRY PULVERIZED COAL	COST OF STEAM ($/THOUSAND LB):	2.00
NO. OF SCRUBBERS:	4	FIRST YEAR CAPITAL CHARGE FACTOR:	0.180
SCRUBBER VELOCITY (FT/M):	750.0	BAGHOUSE RATIO (OPER. SQ.FT./ACTUAL SQ.FT.):	0.80
PLANT SIZE (MW):	500	BAG COST ($/SQ.FT.):	0.70
OPERATING HRS/YR:	5256	BAG LIFE(YEARS):	3.00
PUMPING RATE (GAL/1000 ACF):	20.00	FLUE GAS REHEAT TEMPERATURE (F):	132.
SCA RATIO: (ACTUAL SQ.FT./CALC. SQ.FT.)	1.300	CHEMICAL ENGINEERING PLANT INDEX:	263.0

	ELECTROSTATIC PRECIPITATORS			
	COLD	HOT	BAGHOUSE FABRIC FILTERS	SCRUBBERS
REQUIRED REMOVAL EFFICIENCY (%):	99.70	99.70	99.70	99.70
DRIFT VELOCITY (FT/M):	27.19	20.00		
SPECIFIC COLLECTION AREA (SQ.FT./ACFM):	277.74	377.59		
COLLECTION AREA (SQ.FT.):	468576.7	972309.6	866133.3	
TOTAL CORONA POWER (KW):	663.6	1012.8		
AUXILIARY POWER (KW):	407.4	915.2	490.2	
FAN POWER (KW):	264.0	403.0	1320.1	16039.9
PUMP POWER (KW):				3267.8
TOTAL POWER (KW):	1335.0	2331.0	1810.3	19307.7
OPERATING AIR/CLOTH RATIO:			2.4	
INSTALLED AIR/CLOTH RATIO:			1.9	
REQUIRED PRESSURE DROP (INCHES):	1.0	1.0	5.0	60.8
DIAMETER (FEET):				30
REQUIRED REHEAT (BTU/HR):				6024548.0
STEAM SUPPLY/YR (THOUSAND LB):				35183.4
INSTALLED COST (1979 DOLLARS):	$ 6562679	$ 12176132	$ 16303550	$ 22732816
FIRST YEAR CAPITALIZED COST:	$ 1183469	$ 2195762	$ 2940073	$ 4099484
ANNUAL POWER COST:	$ 203479	$ 355293	$ 275935	$ 2942956
ANNUAL OPERATING AND MAINTENANCE COST (1979 DOLLARS):	$ 112895	$ 169411	$ 73728	$ 1192909
REPLACEMENT COST (1979 DOLLARS):			$ 265128	
ANNUAL REHEAT COST:				$ 70367
TOTAL ANNUAL COST:	$ 1499843	$ 2720466	$ 3554864	$ 8305716
ANNUALIZED COST OF POWER(MILLS/KWHR):	0.57	1.04	1.35	3.16

500 MW

RAW MATERIAL HANDLING AND PREPARATION

ITEM	DESCRIPTION	NO.	MATERIAL	LABOR
CAR SHAKER AND HOIST	20HP SHAKER 7,5HP HOIST	1	61661.	10801.
CAR PULLER	25HP PULLER, 5HP RETURN	1	54039.	16202.
UNLOADING HOPPER	16FT DIA, 10FT STRAIGHT INCLUDES 6 IN SQ GRATEING	1	13297.	4915.
UNLOADING VIBRATING FEEDER	3,5HP	1	4687.	432.
UNLOADING BELT CONVEYOR	20FT HORIZONTAL, 5HP	1	9809.	1188.
UNLOADING INCLINE BELT CONVEYOR	310FT, 50HP	1	73133.	3996.
UNLOADING PIT DUST COLLECTOR	POLYPROPYLENE BAGTYPE, INCLUDES DUST HOOD	1	9591.	4320.
UNLOADING PIT SUMP PUMP	60GPM, 70FT HEAD, 5HP	1	2071.	648.
STORAGE BELT CONVEYOR	200FT, 5HP	1	62670.	3240.
STORAGE CONVEYOR TRIPPER	30FPM, 1HP	1	23324.	7561.
MOBILE EQUIPMENT	SCRAPPER TRACTOR	1	121633.	0.
RECLAIM HOPPER	7FT WIDE, 4,25FT HT, 2FT WIDE BOTTOM, CS	2	2071.	1350.
RECLAIM VIBRATING FEEDER	3.5HP	2	9373.	864.
RECLAIM BELT CONVEYOR	200FT, 5HP	1	35095.	2376.
RECLAIM INCLINE BELT CONVEYOR	193FT, 40HP	1	51661.	3024.
RECLAIM PIT DUST COLLECTOR	POLYPROPYLENE BAG TYPE	1	6648.	2160.
RECLAIM PIT SUMP PUMP	60GPM, 70FT HEAD, 5HP	1	2071.	648.
RECLAIM BUCKET ELEVATOR	90FT HIGH, 75HP	1	37002.	5509.
FEED BIN	13FT DIA, 21FT STRAIGHT SIDE HT, COVERED, CS	2	24741.	13283.
BIN WEIGH FEEDER	14FT PULLEY CENTERS, 2HP	2	28338.	1296.
GYRATORY CRUSHERS	75HP	2	169807.	3564.
BALL MILL DUST COLLECTORS	POLYPROPYLENE BAG TYPE 2200 CFM, 7,5HP	2	13297.	4320.
BALL MILL	11.5TPH, 155.HP	2	325278.	37290.
MILLS PRODUCT TANK	5500 GAL 10FT DIA, 10FT HT, FLAKEGLASS LINED CS	2	7847.	6049.
MILLS PRODUCT TANK AGITATOR	10HP	2	13079.	3024.

MILLS PRODUCT TANK SLURRY PUMP	48.GPM, 60FT HEAD, 2.HP, 2 OPERATING AND 1 SPARES	3	7245.	2268.
SLURRY FEED TANK	51185.GAL, 20.6FT DIA, 20.6FT HT, FLAKEGLASS-LINED CS	1	15700.	12533.
SLURRY FEED TANK AGITATUR	45.HP	1	33805.	2680.
SLURRY FEED TANK PUMPS	24.GPM, 60 FT HEAD, 1.HP, 4 OPERATING AND 2 SPARE	6	13783.	4536.
			----------	----------
TOTAL EQUIPMENT COST			1252774.	160082.

500 MW

SCRUBBING

ITEM	DESCRIPTION	NO.	MATERIAL	LABOR
I.D. FANS	20.0IN H2O, WITH 1482. HP MOTOR AND DRIVE	4	3397185.	47410.
SHELL			1050765.	
RUBBER LINING			1035699.	
MIST ELIMINATOR			214417.	
SLURRY HEADER AND NOZZLES			261525.	
GRIDS			464884.	
SPHERES			633986.	
TOTAL TCA SCRUBBER COSTS		4	3661275.	256251.
SOOTBLOWERS		32	76729.	69127.
EFFLUENT HOLD TANK	251860.GAL, 35.0FT DIA, 35.0FT HT, FLAKEGLASS-LINED CS	4	208159.	162525.
EFFLUENT HOLD TANK AGITATOR	66.HP	4	278604.	88352.
COOLING SPRAY PUMPS	1388.GPM 100FT HEAD, 64.HP, 4 OPERATING AND 4 SPARE	8	71838.	21388.
ABSORBER RECYCLE PUMPS	9540.GPM, 100FT HEAD, 442.HP, 8 OPERATING AND 4 SPARE	12	693000.	74503.
MAKEUP WATER PUMPS	2775.GPM, 200.FT HEAD, 234.HP, 1 OPERATING AND 1 SPARE	2	24300.	2649.
			----------	----------
TOTAL EQUIPMENT COST			8411090.	722206.

500 MW

WASTE DISPUSAL

ITEM	DESCRIPTION	NO.	MATERIAL	LABOR
ABSORBER BLEED RECEIVING TANK	62898.GAL, 17.5FT DIA, 35.0FT HT, FLAKGLASS-LINED CS	1	20720.	16554.
ABSORBER BLEED TANK AGITATOR	38.HP	1	23676.	1877.
THICKENER FEED PUMP	730.GPM, 60FT HEAD, 20.HP, 1 OPERATING AND 1 SPARE	2	13252.	4037.
THICKENER	18318.SQ.FT.,153.FT DIA, 8.6TANK FT HT	1	325295.	337388.
THICKENER UNDERFLOW SLURRY PUMPS	270.GPM, 9.1FT HEAD, 1.HP , 1 OPERATING AND 1 SPARE	2	6683.	2616.
THICKENER OVERFLOW PUMPS	439.GPM, 75.0FT HEAD, 14.HP, 1 OPERATING AND 1 SPARE	2	8559.	933.
THICKENER OVERFLOW TANK	7250.GAL, 12.0FT DIA, 8.6FT HT	1	2588.	1578.
FILTER FEED TANK	4460.GAL, 9.1FT DIA, 9.1FT HT, FLAKEGLASS-LINED CS	1	3086.	2464.
FILTER FEED TANK AGITATOR	7.HP	1	4257.	337.
FILTER FEED SLURRY PUMP	135.GPM, 50FT HEAD, 4.HP, 2 OPERATING AND 1 SPARE	3	10137.	2898.
FILTER	301.SQ FT FILTRATION AREA	2	196139.	36249.
FILTRATE PUMP (PER FILTER)	52.GPM, 20.0FT HEAD, 0.HP, 2 OPERATING AND 2 SPARE	4	14331.	1584.
FILTRATE SURGE TANK	1705.GAL, 6.6FT DIA, 6.6FT HT	1	949.	627.
FILTRATE SURGE TANK PUMP	103.GPM, 85.0FT HEAD, 4.HP, 2 OPERATING AND 2SPARE	2	7606.	829.
TOTAL EQUIPMENT COST			637277.	409972.

500 MW

LIMESTONE SLURRY PROCESS -- BASIS: 500 MW UNIT, 1981 STARTUP

PROJECTED CAPITAL INVESTMENT REQUIREMENTS - EXAMPLE INDUSTRIAL, LIMESTONE, NEW ECONOMIC PREMISES CASE 002

	INVESTMENT, THOUSANDS OF 1980 DOLLARS				DISTRIBUTION
	RAW MATERIAL HANDLING AND PREPARATION	SCRUBBING	WASTE DISPOSAL	TOTAL	PERCENT OF DIRECT INVESTMENT
EQUIPMENT					
MATERIAL	1253.	8411.	637.	10301.	40.1
LABOR	160.	722.	410.	1292.	5.0
PIPING					
MATERIAL	301.	2341.	386.	3028.	11.8
LABOR	140.	319.	146.	604.	2.4
DUCTWORK					
MATERIAL	0.	1953.	0.	1953.	7.6
LABOR	0.	1480.	0.	1480.	5.8
FOUNDATIONS					
MATERIAL	245.	118.	22.	386.	1.5
LABOR	637.	247.	46.	930.	3.6
POND CONSTRUCTION	0.	0.	0.	0.	0.0
STRUCTURAL					
MATERIAL	147.	230.	0.	377.	1.5
LABOR	86.	387.	0.	473.	1.8
ELECTRICAL					
MATERIAL	163.	591.	219.	973.	3.8
LABOR	410.	1050.	674.	2134.	8.3
INSTRUMENTATION					
MATERIAL	93.	468.	40.	602.	2.3
LABOR	13.	78.	54.	146.	0.6
BUILDINGS					
MATERIAL	33.	0.	26.	59.	0.2
LABOR	36.	0.	26.	62.	0.2
SERVICES AND MISCELLANEOUS	129.	638.	93.	860.	3.4
SUBTOTAL DIRECT INVESTMENT	3845.	19033.	2780.	25659.	100.0
ENGINEERING DESIGN AND SUPERVISION	346.	1713.	250.	2309.	9.0
CONSTRUCTION EXPENSES	615.	3045.	445.	4105.	16.0
CONTRACTOR FEES	192.	952.	139.	1283.	5.0
CONTINGENCY	1000.	4949.	723.	6671.	26.0
SUBTOTAL FIXED INVESTMENT	5998.	2962.	4337.	00027.	156.0
ALLOWANCE FOR STARTUP AND MODIFICATIONS	461.	2284.	334.	3079.	12.0
INTEREST DURING CONSTRUCTION	900.	4454.	651.	6004.	23.4
SUBTOTAL CAPITAL INVESTMENT	7359.	36430.	5322.	49110.	191.4
LAND	10.	3.	13.	27.	0.1
WORKING CAPITAL	232.	1149.	168.	1549.	6.0
TOTAL CAPITAL INVESTMENT	7601.	37582.	5503.	50686.	197.5

500 MW

```
LIMESTONE SLURRY PROCESS -- BASIS: 500 MW UNIT, 1981 STARTUP

PROJECTED REVENUE REQUIREMENTS - EXAMPLE INDUSTRIAL, LIMESTONE, NEW ECONOMIC PREMISES              CASE 003

                              DISPLAY SHEET FOR YEAR=    1
                             ANNUAL OPERATION KW-HR/KW =  5256

                   30.13 TONS PER HOUR                          DRY            SLUDGE
                            TOTAL CAPITAL INVESTMENT        49147000                 TOTAL
                                                                                    ANNUAL
                                        ANNUAL QUANTITY       UNIT COST,$          COST,$
                                        ---------------       -----------          ------
    DIRECT COSTS
    ------------
      RAW MATERIAL
      ------------
        LIMESTONE                          121.1 K TONS         8.00/TON            968600
                                                                                ----------
           SUBTOTAL RAW MATERIAL                                                    968600

      CONVERSION COSTS
      ----------------
        OPERATING LABOR AND
          SUPERVISION                     42880.0 MAN-HR       12.50/MAN-HR         536000
        UTILITIES
          PROCESS WATER                  195930.0 K GAL         0.12/K GAL           23500
          ELECTRICITY                  44625570.0 KWH           0.029/KWH          1294100
        MAINTENANCE
          LABOR AND MATERIAL                                                       2052700
        ANALYSES                           4830.0 HR           17.00/HR              82200
        Sludge Disposal                     316.7 K tons       15.00/HR            4750898
           SUBTOTAL CONVERSION COSTS                                               8739398

           SUBTOTAL DIRECT COSTS                                                   9707998

    INDIRECT COSTS
    --------------
      OVERHEADS
        PLANT AND ADMINISTRATIVE (  60.0% OF CONVERSION COSTS LESS UTILITIES)      4453079
                                                                                ----------
      FIRST YEAR OPERATING AND MAINTENANCE COSTS                                  14161077
      LEVELIZED CAPITAL CHARGES( 14.7% OF TOTAL CAPITAL INVESTMENT)                7450842
                                                                                ----------
         FIRST YEAR ANNUAL REVENUE REQUIREMENTS                                   21611919




---------------------------------------------------------------------------------------------------------
      HEAT RATE   9500. BTU/KWH    -    HEAT VALUE OF COAL     11700 BTU/LB    -     COAL RATE   1066900 TONS/YR
```

1000 MW

```
EXAMPLE INDUSTRIAL, LIMESTONE, NEW ECONOMIC PREMISES                    CASE 004

                    *** INPUTS ***

BOILER CHARACTERISTICS
------ ---------------

MEGAWATTS =  1000.     INDUSTRIAL BASIS

BOILER HEAT RATE =  9500. BTU/KWH

EXCESS AIR =  39. PERCENT, INCLUDING LEAKAGE

HOT GAS TEMPERATURE = 300. DEG F

COAL ANALYSIS, WT % AS FIRED :

 C       H       O       N       S       CL     ASH     H2O
66.70   3.80    5.60    1.30    3.36    0.10   15.10    4.00

SULFUR OVERHEAD =  92.0 PERCENT

ASH OVERHEAD =  80.0 PERCENT

HEATING VALUE OF COAL = 11700. BTU/LB

                          EFFICIENCY,    EMISSION,
FLYASH REMOVAL                 %         LBS/M BTU
------ -------            -----------    ---------

UPSTREAM OF SCRUBBER         99.7           0.03

WITHIN SCRUBBER              50.0           0.02

COST OF UPSTREAM FLYASH REMOVAL EXCLUDED


ALKALI
------

LIMESTONE :

        CACO3         =  97.15 WT % DRY BASIS
        SOLUBLE MGO =    0.0
        INERTS        =    2.85
        MOISTURE CONTENT =    5.00 LB H2O/100 LBS DRY LIMESTONE
        LIMESTONE HARDNESS WORK INDEX FACTOR = 10.00
        LIMESTONE DEGREE OF GRIND FACTOR =  1.35

FLY ASH :

        SOLUBLE CAO =    0.0  WT %
        SOLUBLE MGO =    0.0
        INERTS        = 100.00


RAW MATERIAL HANDLING AREA
--- -------- -------- ----

NUMBER OF REDUNDANT ALKALI PREPARATION UNITS =     0
```

1000 MW

```
SCRUBBER SYSTEM VARIABLES
-------- ------ ---------

NUMBER OF OPERATING SCRUBBING TRAINS =   8

NUMBER OF REDUNDANT SCRUBBING TRAINS =   0

NUMBER OF BEDS =   3

NUMBER OF GRIDS =   4

HEIGHT OF SPHERES PER BED =  5,0 INCHES

LIQUID-TO-GAS RATIO =  55, GAL/1000 ACF(SATD)

SCRUBBER GAS VELOCITY = 12.5 FT/SEC

INDUCED DRAFT SCRUBBER FAN OPTION

SCRUBBER PRESSURE = 14,7 PSIA

STOICHIOMETRY =  1.25 MOLE CACO3 ADDED AS LIMESTONE
                      PER MOLE (SO2+2HCL) ABSORBED

SO2 REMOVAL =  90, PERCENT

ENTRAINMENT LEVEL = 0,10 WT %

EHT RESIDENCE TIME =  12,0 MIN

SO2 OXIDIZED IN SYSTEM =  30,0 PERCENT

SOLIDS IN RECIRCULATED SLURRY =  15,0 WT %


SOLIDS DISPOSAL SYSTEM
------ -------- ------

COST OF LAND =  5000,00 DOLLARS/ACRE

SOLIDS IN SYSTEM SLUDGE DISCHARGE =  50,0 WT %

SOLIDS IN CLARIFIER DISCHARGE = 35,0 WT %

CLARIFIER SOLIDS SETTLING RATE = 0,20 FT/HR

SOLIDS IN FILTER CAKE = 50,0 WT %

FILTRATION RATE = 1,20 TONS DRY SOLIDS/FT2 DAY


NO REHEATERS
-- ---------
```

1000 MW

```
EXAMPLE INDUSTRIAL, LIMESTONE, NEW ECONOMIC PREMISES                      CASE 004

                        *** OUTPUTS ***

    HOT GAS TO SCRUBBER
    --- --- -- --------

              MOLE PERCENT      LB-MOLE/HR       LB/HR

    CO2          12.338         0,4509E+05       0.1985E+07
    HCL           0,006         0,2290E+02       0,8351E+03
    SO2           0,214         0,7829E+03       0,5015E+05
    O2            5,560         0,2032E+05       0,6502E+06
    N2           75,227         0.2749E+06       0,7704E+07
    H2O           6,654         0,2432E+05       0,4381E+06

    SO2 CONCENTRATION IN SCRUBBER INLET GAS = 2142. PPM
                                            = 5,28 LBS / MILLION BTU

    FLYASH EMISSION =  0.03 LBS/MILLION BTU
                    =  0,015 GRAINS/SCF (WET)  OR     294. LB/HR

           SOLUBLE CAO IN FLY ASH =      0. LB/HR
           SOLUBLE MGO IN FLY ASH =      0,

    HOT GAS FLOW RATE =  ,2309E+07 SCFM (60 DEG F, 14.7 PSIA)
                      =  ,3374E+07 ACFM (300. DEG F, 14.7 PSIA)

    CORRESPONDING COAL FIRING RATE =  ,8120E+06 LB/HR

    HOT GAS HUMIDITY =  0.042 LB H2O/LB DRY GAS

    WET BULB TEMPERATURE = 124. DEG F


    WET GAS FROM SCRUBBER
    --- --- ---- --------

              MOLE PERCENT      LB-MOLE/HR       LB/HR

    CO2          11,716         0,4582E+05       0,2017E+07
    HCL           0.000         0,1145E+01       0,4175E+02
    SO2           0,020         0,7829E+02       0,5015E+04
    O2            5.169         0,2021E+05       0,6469E+06
    N2           70,300         0,2749E+06       0,7704E+07
    H2O          12.795         0,5004E+05       0,9015E+06

    SO2 CONCENTRATION IN SCRUBBER OUTLET GAS =  200. PPM

    FLYASH EMISSION =  0.02 LBS/MILLION BTU
                    =  0,007 GRAINS/SCF (WET)  OR     147. LB/HR

    TOTAL WATER PICKUP =  950.  GPM
               INCLUDING   22.5 GPM ENTRAINMENT

    WET GAS FLOW RATE =  .2470E+07 SCFM (60 DEG F, 14.7 PSIA)
                      =  .2775E+07 ACFM (124. DEG F, 14.7 PSIA)

    WET GAS SATURATION HUMIDITY =  0,097 LB H2O/LB DRY GAS
```

1000 MW

```
FLUE GAS TO STACK
---- --- -- -----

              MOLE PERCENT     LB-MOLE/HR      LB/HR

CO2             11.697        0.4582E+05     0.2017E+07
HCL              0.000        0.1145E+01     0.4175E+02
SO2              0.020        0.7829E+02     0.5015E+04
O2               5.160        0.2021E+05     0.6469E+06
N2              70.188        0.2749E+06     0.7704E+07
H2O             12.934        0.5067E+05     0.9128E+06

SPECIFIED  SO2 REMOVAL EFFICIENCY =  90.0 %

CALCULATED SO2 EMISSION =   0.53 POUNDS PER MILLION BTU

CALCULATED SO2 CONCENTRATION IN STACK GAS =     200. PPM

FLYASH EMISSION =  0.02 LBS/MILLION BTU
                =  0.007 GRAINS/SCF (WET)  OR    147. LB/HR

STACK GAS FLOW RATE =  .2474E+07 SCFM (60 DEG F, 14.7 PSIA)
                    =  .2819E+07 ACFM (132. DEG F, 14.7 PSIA)
```

1000 MW

```
WATER BALANCE INPUTS
----- ------- ------

  RAINFALL(IN/YEAR)                         50.
  POND SEEPAGE(CM/SEC)*10**8                50.
  POND EVAPORATION(IN/YEAR)                 32.


WATER BALANCE OUTPUTS
----- ------- -------

WATER AVAILABLE

  RAINFALL                                   2. GPM              1086. LB/HR
  ALKALI                                     9. GPM              4607. LB/HR
      TOTAL                                 11. GPM              5693. LB/HR

WATER REQUIRED

  HUMIDIFICATION                           927. GPM            463391. LB/HR
  ENTRAINMENT                               23. GPM             11260. LB/HR
  DISPOSAL WATER                           238. GPM            119105. LB/HR
  HYDRATION WATER                           24. GPM             12014. LB/HR
  CLARIFIER EVAPORATION                     42. GPM             20965. LB/HR
  POND EVAPORATION                           0. GPM                 0. LB/HR
  SEEPAGE                                    0. GPM                 0. LB/HR

  TOTAL WATER REQUIRED                    1254. GPM            626736. LB/HR

NET WATER REQUIRED                        1243. GPM            621043. LB/HR
```

1000 MW

```
SCRUBBER SYSTEM
-------- ------

TOTAL NUMBER OF SCRUBBING TRAINS (OPERATING+REDUNDANT) =  8

SO2 REMOVAL =  90.0 PERCENT

PARTICULATE REMOVAL IN SCRUBBER SYSTEM =  50.0 PERCENT

TCA PRESSURE DROP ACROSS  3 BEDS =  8.6 IN. H2O

TOTAL SYSTEM PRESSURE DROP = 13.9 IN. H2O

OVERRIDE TOTAL SYSTEM PRESSURE DROP = 20.0 IN. H2O

SPECIFIED  LIQUID-TO-GAS-RATIO    =  55. GAL/1000 ACF(SATD)

LIMESTONE ADDITION = 0.9214E+05 LB/HR DRY LIMESTONE

SPECIFIED  LIMESTONE STOICHIOMETRY  =  1.25 MOLE CACO3 ADDED AS LIMESTONE
                                            PER MOLE (SO2+2HCL) ABSORBED

SOLUBLE CAO FROM FLY ASH =  0.0  MOLE PER MOLE (SO2+2HCL) ABSORBED

TOTAL SOLUBLE MGO        =  0.0  MOLE PER MOLE (SO2+2HCL) ABSORBED

TOTAL STOICHIOMETRY      =  1.25 MOLE SOLUBLE (CA+MG)
                                 PER MOLE (SO2+2HCL) ABSORBED

SCRUBBER INLET LIQUOR PH =  5.66

MAKE UP WATER = 1243. GPM

CROSS-SECTIONAL AREA PER SCRUBBER =   463. SQ FT
```

1000 MW

```
SOLIDS DISPOSAL SYSTEM
------ -------- ------

TOTAL CLARIFIER(S) CROSS-SECTIONAL AREA =  36636. SQ FT

SYSTEM SLUDGE DISCHARGE
------ ------ ---------                            SOLID     LIQUID
                                                  COMP,     COMP,
SPECIES           LB-MOLE/HR    LB/HR            WT %      PPM

CASO3 ,1/2 H2O    0,4932E+03    0,6367E+05       52.84
CASO4 ,2H2O       0,2101E+03    0,3616E+05       30.01
CACO3             0,1788E+03    0,1790E+05       14.86
INSOLUBLES        ----------    0,2773E+04        2,30
H2O               0,6611E+04    0,1191E+06
CA++              0,1244E+02    0,4985E+03                 4136.
MG++              0,0           0,0                           0.
SO3--             0,1898E+00    0,1519E+02                  126.
SO4--             0,1314E+01    0,1262E+03                 1047.
CL-               0,2176E+02    0,7714E+03                 6401.


TOTAL DISCHARGE FLOW RATE = 0,2410E+06 LB/HR
                          =   334.     GPM

TOTAL DISSOLVED SOLIDS IN DISCHARGE LIQUID =  11697. PPM

DISCHARGE LIQUID PH =  7,28
```

```
SCRUBBER SLURRY BLEED
-------- ------ -----

SPECIES             LB-MOLE/HR   LB/HR

CASO3 .1/2 H2O      0.4932E+03   0.6367E+05
CASO4 .2H2O         0.2101E+03   0.3616E+05
CACO3               0.1788E+03   0.1790E+05
INSOLUBLES          ----------   0.2773E+04
H2O                 0.3746E+05   0.6749E+06
CA++                0.7047E+02   0.2825E+04
MG++                0.0          0.0
SO3--               0.1075E+01   0.8609E+02
SO4--               0.7444E+01   0.7151E+03
CL-                 0.1233E+03   0.4371E+04
AD=                 0.0          0.0

TOTAL FLOW RATE = 0.8034E+06 LB/HR
                =   1459.     GPM


TOTAL SUPERNATE RETURN
----- --------- ------

SPECIES             LB-MOLE/HR   LB/HR

H2O                 0.2976E+05   0.5362E+06
CA++                0.5599E+02   0.2244E+04
MG++                0.0          0.0
SO3--               0.8543E+00   0.6840E+02
SO4--               0.5914E+01   0.5681E+03
CL-                 0.9795E+02   0.3472E+04
AD=                 0.0          0.0

TOTAL FLOW RATE = 0.5425E+06 LB/HR
                =   1085.     GPM


SUPERNATE TO WET BALL MILL
--------- -- --- ---- ----

SPECIES             LB-MOLE/HR   LB/HR

H2O                 0.3123E+04   0.5626E+05
CA++                0.5875E+01   0.2355E+03
MG++                0.0          0.0
SO3--               0.8965E-01   0.7177E+01
SO4--               0.6206E+00   0.5961E+02
CL-                 0.1028E+02   0.3644E+03
AD=                 0.0          0.0

TOTAL FLOW RATE = 0.5693E+05 LB/HR
                =    114.     GPM
```

1000 MW

```
LIMESTONE SLURRY FEED
--------- ------ ----

SPECIES              LB-MOLE/HR    LB/HR

CACO3                0.8943E+03    0.8932E+05
SOLUBLE MGO          0.0           0.0
INSOLUBLES           ----------    0.2626E+04
H2O                  0.3370E+04    0.6071E+05
CA++                 0.5875E+01    0.2355E+03
MG++                 0.0           0.0
SO3--                0.8965E-01    0.7177E+01
SO4--                0.6206E+00    0.5961E+02
CL-                  0.1028E+02    0.3644E+03
AD=                  0.0           0.0

TOTAL FLOW RATE = 0.1536E+06 LB/HR
                =     194.      GPM


SUPERNATE RETURN TO SCRUBBER OR EHT
--------- ------ -- -------- -- ---

SPECIES              LB-MOLE/HR    LB/HR

H2O                  0.2664E+05    0.4799E+06
CA++                 0.5011E+02    0.2008E+04
MG++                 0.0           0.0
SO3--                0.7647E+00    0.6122E+02
SO4--                0.5293E+01    0.5085E+03
CL-                  0.8768E+02    0.3108E+04
AD=                  0.0           0.0

TOTAL FLOW RATE = 0.4856E+06 LB/HR
                =     972.      GPM


RECYCLE SLURRY TO SCRUBBER
------- ------ -- --------

SPECIES              LB-MOLE/HR    LB/HR

CASO3 .1/2 H2O       0.5159E+05    0.6661E+07
CASO4 .2H2O          0.2198E+05    0.3783E+07
CACO3                0.1871E+05    0.1873E+07
INSOLUBLES           ----------    0.2901E+06
H2O                  0.3919E+07    0.7060E+08
CA++                 0.7372E+04    0.2955E+06
MG++                 0.0           0.0
SO3--                0.1125E+03    0.9006E+04
SO4--                0.7787E+03    0.7480E+05
CL-                  0.1290E+05    0.4572E+06
AD=                  0.0           0.0

TOTAL FLOW RATE = 0.8404E+08 LB/HR
                = 152643.       GPM
```

1000 MW

```
FLUE GAS COOLING SLURRY
---- --- ------- ------

SPECIES           LB-MOLE/HR    LB/HR

CASO3 .1/2 H2O    0.3752E+04    0.4844E+06
CASO4 .2H2O       0.1599E+04    0.2751E+06
CACO3             0.1361E+04    0.1362E+06
INSOLUBLES        ----------    0.2110E+05
H2O               0.2850E+06    0.5135E+07
CA++              0.5361E+03    0.2149E+05
MG++              0.0           0.0
SO3--             0.8181E+01    0.6550E+03
SO4--             0.5663E+02    0.5440E+04
CL-               0.9381E+03    0.3325E+05
AD=               0.0           0.0

TOTAL FLOW RATE = 0.6112E+07 LB/HR
                =  11101.     GPM


CLARIFIER UNDERFLOW SLURRY
--------- --------- ------

SPECIES           LB-MOLE/HR    LB/HR

CASO3 .1/2 H2O    0.4932E+03    0.6367E+05
CASO4 .2H2O       0.2101E+03    0.3616E+05
CACO3             0.1788E+03    0.1790E+05
INSOLUBLES        ----------    0.2773E+04
H2O               0.1228E+05    0.2212E+06
CA++              0.2310E+02    0.9257E+03
MG++              0.0           0.0
SO3--             0.3524E+00    0.2822E+02
SO4--             0.2440E+01    0.2344E+03
CL-               0.4041E+02    0.1433E+04
AD=               0.0           0.0

TOTAL FLOW RATE = 0.3443E+06 LB/HR
                =    541.     GPM


SUPERNATE FROM CLARIFIER
--------- ---- ---------

SPECIES           LB-MOLE/HR    LB/HR

CASO3 .1/2 H2O    0.0           0.0
CASO4 .2H2O       0.0           0.0
CACO3             0.0           0.0
INSOLUBLES        ----------    0.0
H2O               0.2409E+05    0.4341E+06
CA++              0.4533E+02    0.1817E+04
MG++              0.0           0.0
SO3--             0.6916E+00    0.5537E+02
SO4--             0.4788E+01    0.4599E+03
CL-               0.7930E+02    0.2811E+04
AD=               0.0           0.0

TOTAL FLOW RATE = 0.4392E+06 LB/HR
```

1000 MW

```
                    =   879   GPM

FILTER CAKE SLURRY
------ ---- ------
SPECIES              LB-MOLE/HR    LB/HR

CASO3 ,1/2 H2O       0,4932E+03    0,6367E+05
CASO4 ,2H2O          0,2101E+03    0,3616E+05
CACO3                0,1788E+03    0,1790E+05
INSOLUBLES           ----------    0,2773E+04
H2O                  0,6611E+04    0,1191E+06
CA++                 0,1244E+02    0,4985E+03
MG++                 0,0           0,0
SO3--                0,1898E+00    0,1519E+02
SO4--                0,1314E+01    0,1262E+03
CL-                  0,2176E+02    0,7714E+03
AD=                  0,0           0,0

TOTAL FLOW RATE = 0,2410E+06 LB/HR
                =    334,    GPM

FILTRATE FROM FILTER
-------- ---- ------
SPECIES              LB-MULE/HR    LB/HR

CASO3 ,1/2 H2O       0,0           0,0
CASO4 ,2H2O          0,0           0,0
CACO3                0,0           0,0
INSOLUBLES           ----------    0,0
H2O                  0,5667E+04    0,1021E+06
CA++                 0,1066E+02    0,4272E+03
MG++                 0,0           0,0
SO3--                0,1627E+00    0,1302E+02
SO4--                0,1126E+01    0,1082E+03
CL-                  0,1865E+02    0,6612E+03
AD=                  0,0           0,0

TOTAL FLOW RATE = 0,1033E+06 LB/HR
                =    207,    GPM
```

1000 MW

```
        EXAMPLE INDUSTRIAL, LIMESTONE, NEW ECONOMIC PREMISES                 CASE 004

                         PARTICULATE REMOVAL INVESTMENT AND OPERATING COST
                                                   PARTICULATE EMISSION REGULATION (LB ASH/MILLION BTU):   0.03
  WPSUL CONTENT (%):              3.36             FLUE GAS TEMPERATURE (COLD) (F):                      300.0
  ASH CONTENT (%):               15.10             FLUE GAS TEMPERATURE (HOT) (F):                       700.0
  BTU RATING:                    11700             COST OF ELECTRICITY ($/KWHR):                           0.03
  BOILER TYPE:                   DRY PULVERIZED COAL COST OF STEAM ($/THOUSAND LB):                        2.00
  NO. OF SCRUBBERS:                  8             FIRST YEAR CAPITAL CHARGE FACTOR:                       0.180
  SCRUBBER VELOCITY (FT/M):      750.0             BAGHOUSE RATIO (OPER. SQ.FT./ACTUAL SQ.FT.):            0.80
  PLANT SIZE (MW):                1000             BAG COST ($/SQ.FT.):                                    0.70
  OPERATING HRS/YR:               5256             BAG LIFE(YEARS):                                      3.00
  PUMPING RATE (GAL/1000 ACF):   20.00             FLUE GAS REHEAT TEMPERATURE (F):                      132.
  SCA RATIO:                     1.300             CHEMICAL ENGINEERING PLANT INDEX:                     263.0
    (ACTUAL SQ.FT./CALC. SQ.FT.)


                              ELECTROSTATIC PRECIPITATORS
                                        COLD           HOT         BAGHOUSE FABRIC FILTERS     SCRUBBERS

  REQUIRED REMOVAL EFFICIENCY (%):     99.70          99.70              99.70                  99.70
  DRIFT VELOCITY (FT/M):               27.19          20.00
  SPECIFIC COLLECTION AREA (SQ.FT./ACFM): 277.74     377.59
  COLLECTION AREA (SQ.FT.):        937153.9      1944619.0           1732267.0
  TOTAL CORONA POWER (KW):           1327.1         2025.6
  AUXILIARY POWER (KW):               878.5         1973.7               775.8
  FAN POWER (KW):                     528.0          803.9              2640.2                32079.9
  PUMP POWER (KW):                                                                             6535.5
  TOTAL POWER (KW):                  2733.7         4803.3              3415.9                38615.4
  OPERATING AIR/CLOTH RATIO:                                               2.4
  INSTALLED AIR/CLOTH RATIO:                                               1.9
  REQUIRED PRESSURE DROP (INCHES):      1.0            1.0                 5.0                   60.8
  DIAMETER (FEET):                                                                                 30
  REQUIRED REHEAT (BTU/HR):                                                                12049106.0
  STEAM SUPPLY/YR (THOUSAND LB):                                                              70366.7
  INSTALLED COST (1979 DOLLARS):  $ 12109651     $ 22514496         $ 29010704             $ 40588688
  FIRST YEAR CAPITALIZED COST:    $  2183773     $  4060113         $  5231396             $  7319492
  ANNUAL POWER COST:              $   416685     $   732438         $   520673             $  5885915
  ANNUAL OPERATING AND
   MAINTENANCE COST (1979 DOLLARS): $ 165977     $   249066         $   110662             $  2129900
  REPLACEMENT COST (1979 DOLLARS):                                  $   530257
  ANNUAL REHEAT COST:                                                                      $   140734


  TOTAL ANNUAL COST:              $  2766435     $  5041617         $  6393188             $ 15476041
  ANNUALIZED COST OF POWER(MILLS/KWHR):  0.53         0.96               1.22                   2.94
```

RAW MATERIAL HANDLING AND PREPARATION

ITEM	DESCRIPTION	NO.	MATERIAL	LABOR
CAR SHAKER AND HOIST	20HP SHAKER 7.5HP HOIST	1	61661.	10801.
CAR PULLER	25HP PULLER, 5HP RETURN	1	54059.	16202.
UNLOADING HOPPER	16FT DIA, 10FT STRAIGHT INCLUDES 6 IN SQ GRATEING	1	13297.	4915.
UNLOADING VIBRATING FEEDER	3.5HP	1	4687.	432.
UNLOADING BELT CONVEYOR	20FT HORIZONTAL, 5HP	1	9809.	1188.
UNLOADING INCLINE BELT CONVEYOR	310FT, 50HP	1	73133.	3996.
UNLOADING PIT DUST COLLECTOR	POLYPROPYLENE BAGTYPE, INCLUDES DUST HOOD	1	9591.	4320.
UNLOADING PIT SUMP PUMP	60GPM, 70FT HEAD, 5HP	1	2071.	648.
STORAGE BELT CONVEYOR	300FT, 7HP	1	87465.	4861.
STORAGE CONVEYOR TRIPPER	30FPM, 1HP	1	23324.	7561.
MOBILE EQUIPMENT	SCRAPPER TRACTOR	1	121633.	0.
RECLAIM HOPPER	7FT WIDE, 4.25FT HT, 2FT WIDE BOTTOM, CS	3	3106.	2025.
RECLAIM VIBRATING FEEDER	3.5HP	3	14060.	1296.
RECLAIM BELT CONVEYOR	300FT, 7HP	1	50572.	3564.
RECLAIM INCLINE BELT CONVEYOR	193FT, 40HP	1	51661.	3024.
RECLAIM PIT DUST COLLECTOR	POLYPROPYLENE BAG TYPE	1	6648.	2160.
RECLAIM PIT SUMP PUMP	60GPM, 70FT HEAD, 5HP	1	2071.	648.
RECLAIM BUCKET ELEVATOR	90FT HIGH, 75HP	1	57002.	5509.
FEED BIN	13FT DIA, 21FT STRAIGHT SIDE HT, COVERED, CS	2	24741.	13285.
BIN WEIGH FEEDER	14FT PULLEY CENTERS, 2HP	2	28338.	1296.
GYRATORY CRUSHERS	75HP	2	169807.	3564.
BALL MILL DUST COLLECTORS	POLYPROPYLENE BAG TYPE 2200 CFM, 7.5HP	2	13297.	4320.
BALL MILL	23.0TPH, 311.HP	2	437624.	45802.
MILLS PRODUCT TANK	5500 GAL 10FT DIA, 10FT HT, FLAKEGLASS LINED CS	2	7847.	6049.
MILLS PRODUCT TANK AGITATOR	10HP	2	13079.	3024.

MILLS PRODUCT TANK SLURRY PUMP	97.GPM, 60FT HEAD, 4.HP, 2 OPERATING AND 1 SPARES	3	10186.	2507.
SLURRY FEED TANK	102370.GAL, 25.9FT DIA, 25.9FT HT, FLAKEGLASS-LINED CS	1	24921.	19894.
SLURRY FEED TANK AGITATUR	72.HP	1	55206.	4377.
SLURRY FEED TANK PUMPS	24.GPM, 60 FT HEAD, 1.HP, 8 OPERATING AND 4 SPARE	12	27566.	9073.
			----------	----------
TOTAL EQUIPMENT COST			1458459.	186343.

SCRUBBING

ITEM	DESCRIPTION	NO.	MATERIAL	LABOR
I.D. FANS	20.0IN H2O, WITH 1482. HP MOTOR AND DRIVE	8	6794377.	94820.
SHELL			2101532.	
RUBBER LINING			2071400.	
MIST ELIMINATOR			428835.	
SLURRY HEADER AND NOZZLES			523051.	
GRIDS			929769.	
SPHERES			1267972.	
TOTAL TCA SCRUBBER COSTS		8	7322559.	512502.
SOOTBLOWERS		64	153459.	138255.
EFFLUENT HOLD TANK	251861.GAL, 35.0FT DIA, 35.0FT HT, FLAKEGLASS-LINED CS	8	416318.	325050.
EFFLUENT HOLD TANK AGITATOR	66.HP	8	557209.	353410.
COOLING SPRAY PUMPS	1388.GPM 100FT HEAD, 64.HP, 8 OPERATING AND 8 SPARE	16	143677.	42776.
ABSORBER RECYCLE PUMPS	9540.GPM, 100FT HEAD, 442.HP, 16 OPERATING AND 8 SPARE	24	1386001.	149007.
MAKEUP WATER PUMPS	5551.GPM, 200.FT HEAD, 468.HP, 1 OPERATING AND 1 SPARE	2	57353.	6252.
			---------	---------
TOTAL EQUIPMENT COST			16830896.	1622069.

WASTE DISPOSAL

ITEM	DESCRIPTION	NO.	MATERIAL	LABOR
ABSORBER BLEED RECEIVING TANK	62898.GAL, 17.5FT DIA, 35.0FT HT, FLAKGLASS-LINED CS	1	20720.	16554.
ABSORBER BLEED TANK AGITATOR	30.HP	1	23676.	1877.
THICKENER FEED PUMP	1459.GPM, 60FT HEAD, 41.HP, 1 OPERATING AND 1 SPARE	2	15865.	5466.
THICKENER	36636.SQ.FT.,216.FT DIA, 10.5TANK FT HT	1	562891.	602732.
THICKENER UNDERFLOW SLURRY PUMPS	541.GPM, 11.5FT HEAD, 3.HP , 1 OPERATING AND 1 SPARE	2	7049.	3548.
THICKENER OVERFLOW PUMPS	879.GPM, 75.0FT HEAD, 28.HP, 1 OPERATING AND 1 SPARE	2	9650.	1058.
THICKENER OVERFLOW TANK	14500.GAL, 15.3FT DIA, 10.5FT HT	1	3775.	2494.
FILTER FEED TANK	8921.GAL, 11.5FT DIA, 11.5FT HT, FLAKEGLASS-LINED CS	1	4899.	3911.
FILTER FEED TANK AGITATOR	10.HP	1	8072.	640.
FILTER FEED SLURRY PUMP	270.GPM, 50FT HEAD, 7.HP, 2 OPERATING AND 1 SPARE	3	11199.	3924.
FILTER	603.SQ FT FILTRATION AREA	2	268148.	41489.
FILTRATE PUMP (PER FILTER)	103.GPM, 20.0FT HEAD, 1.HP, 2 OPERATING AND 2 SPARE	4	14816.	1615.
FILTRATE SURGE TANK	3410.GAL, 8.3FT DIA, 8.3FT HT	1	1506.	995.
FILTRATE SURGE TANK PUMP	207.GPM, 85.0FT HEAD, 7.HP, 2 OPERATING AND 2SPARE	2	7979.	870.
TOTAL EQUIPMENT COST			960244.	687160.

1000 MW

LIMESTONE SLURRY PROCESS -- BASIS: 1000 MW UNIT, 1981 STARTUP

PROJECTED CAPITAL INVESTMENT REQUIREMENTS - EXAMPLE INDUSTRIAL, LIMESTONE, NEW ECONOMIC PREMISES CASE 004

	INVESTMENT, THOUSANDS OF 1980 DOLLARS				DISTRIBUTION
	RAW MATERIAL HANDLING AND PREPARATION	SCRUBBING	WASTE DISPOSAL	TOTAL	PERCENT OF DIRECT INVESTMENT
EQUIPMENT					
MATERIAL	1458.	16831.	960.	19250.	42.0
LABOR	186.	1622.	687.	2496.	5.4
PIPING					
MATERIAL	441.	4681.	525.	5647.	12.3
LABOR	195.	638.	183.	1016.	2.2
DUCTWORK					
MATERIAL	0.	3997.	0.	3997.	8.7
LABOR	0.	3056.	0.	3056.	6.7
FOUNDATIONS					
MATERIAL	290.	236.	24.	551.	1.2
LABOR	771.	494.	51.	1315.	2.9
POND CONSTRUCTION	0.	0.	0.	0.	0.0
STRUCTURAL					
MATERIAL	177.	460.	0.	636.	1.4
LABOR	93.	774.	0.	867.	1.9
ELECTRICAL					
MATERIAL	160.	1040.	243.	1444.	3.1
LABOR	362.	1818.	782.	2962.	6.5
INSTRUMENTATION					
MATERIAL	127.	923.	41.	1092.	2.4
LABOR	19.	157.	54.	230.	0.5
BUILDINGS					
MATERIAL	50.	0.	52.	101.	0.2
LABOR	53.	0.	53.	106.	0.2
SERVICES AND MISCELLANEOUS	109.	916.	91.	1116.	2.4
SUBTOTAL DIRECT INVESTMENT	4492.	37643.	3746.	45882.	100.0
ENGINEERING DESIGN AND SUPERVISION	404.	3388.	337.	4129.	9.0
CONSTRUCTION EXPENSES	719.	6023.	599.	7341.	16.0
CONTRACTOR FEES	225.	1882.	187.	2294.	5.0
CONTINGENCY	1168.	9787.	974.	11929.	260.0
SUBTOTAL FIXED INVESTMENT	7008.	58723.	5843.	71575.	156.0
ALLOWANCE FOR STARTUP AND MODIFICATIONS	539.	4517.	450.	5506.	12.0
INTEREST DURING CONSTRUCTION	1051.	8809.	877.	10736.	23.4
SUBTOTAL CAPITAL INVESTMENT	8598.	72049.	7170.	87817.	191.4
LAND	11.	6.	24.	42.	0.1
WORKING CAPITAL	269.	2256.	224.	2749.	6.0
TOTAL CAPITAL INVESTMENT	8878.	74311.	7418.	90608.	197.5

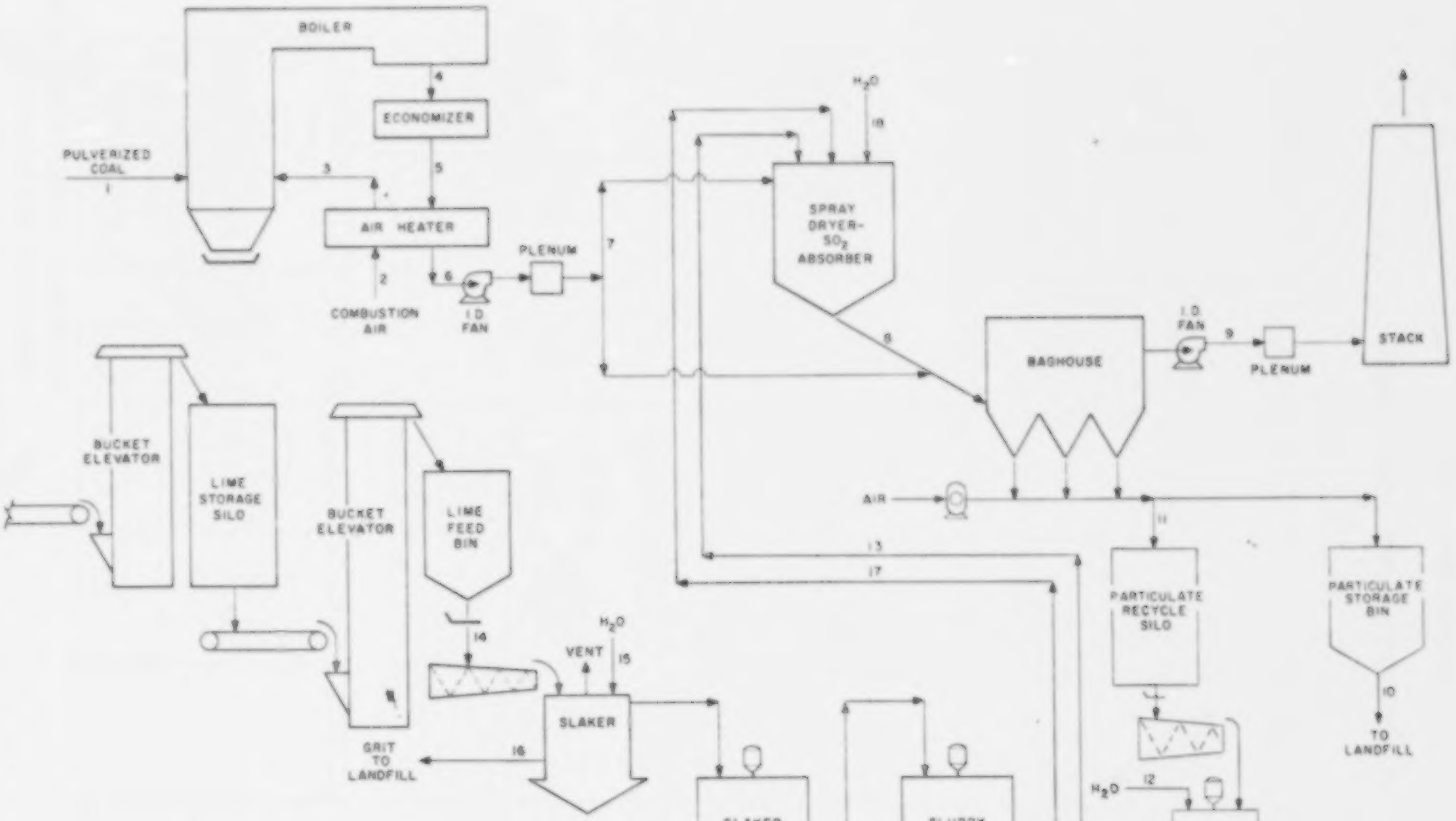
1000 MW

```
LIMESTONE SLURRY PROCESS -- BASIS: 1000 MW UNIT, 1981 STARTUP

PROJECTED REVENUE REQUIREMENTS - EXAMPLE INDUSTRIAL, LIMESTONE, NEW ECONOMIC PREMISES          CASE 004

                              DISPLAY SHEET FOR YEAR=    1
                              ANNUAL OPERATION KW-HR/KW =  5256

                    60.26 TONS PER HOUR                        DRY              SLUDGE
                         TOTAL CAPITAL INVESTMENT       87855000                    TOTAL
                                                                                    ANNUAL
                                             ANNUAL QUANTITY     UNIT COST,$        COST,$
       DIRECT COSTS                          ---------------     -----------        ------
       ------------
         RAW MATERIAL
         ------------
           LIMESTONE                          242.1 K TONS        8.00/TON          1937200
                                                                                  ---------
              SUBTOTAL RAW MATERIAL                                                 1937200

         CONVERSION COSTS
         ----------------
           OPERATING LABOR AND
             SUPERVISION                      53900.0 MAN-HR      12.50/MAN-HR       673700
           UTILITIES
             PROCESS WATER                   391860.0 K GAL        0.12/K GAL         47000
             ELECTRICITY                   86886370.0 KWH          0.029/KWH        2519700
           MAINTENANCE
             LABOR AND MATERIAL                                                     3670500
           ANALYSES                            6440.0 HR          17.00/HR           109600
            Solids Disposal                     633.5 K tons      15.00/TON         9501797
              SUBTOTAL CONVERSION COSTS                                            16522297

              SUBTOTAL DIRECT COSTS                                                18459497

       INDIRECT COSTS
       --------------
         OVERHEADS
           PLANT AND ADMINISTRATIVE (  60.0% OF CONVERSION COSTS LESS UTILITIES)    8373358
                                                                                  ---------
         FIRST YEAR OPERATING AND MAINTENANCE COSTS                                26832855
         LEVELIZED CAPITAL CHARGES(  14.7% OF TOTAL CAPITAL INVESTMENT)            13319376
                                                                                  ---------
              FIRST YEAR ANNUAL   COSTS                                            40152231

-----------------------------------------------------------------------------------------------------------
       HEAT RATE   9500, BTU/KWH     -     HEAT VALUE OF COAL     11700 BTU/LB     -    COAL RATE   2133800 TONS/YR
```

APPENDIX D

UTILITY BOILER LIME DRY SCRUBBING FGD SYSTEM PREMISES

MATERIAL BALANCE FOR 0.7% SULFUR COAL - 70% SULFUR REMOVAL
1982 BARE EQUIPMENT COSTS
EQUIPMENT INSTALLATION FACTORS
SCALE FACTORS
1982 CAPITAL INVESTMENT
OPERATING LABOR & SUPERVISION ASSUMPTIONS
ANNUAL O&M COSTS
1984 ANNUAL REVENUE REQUIREMENT


BOILER
PULVERIZED COAL
1
2
3
4
5
6
ECONOMIZER
AIR HEATER
COMBUSTION AIR
I.D. FAN
PLENUM
7
H₂O
18
SPRAY DRYER-SO₂ ABSORBER
8
BAGHOUSE
I.D. FAN
9
PLENUM
STACK
BUCKET ELEVATOR
LIME STORAGE SILO
BUCKET ELEVATOR
LIME FEED BIN
14
VENT
H₂O
15
SLAKER
16
GRIT TO LANDFILL
AIR
13
17
11
PARTICULATE RECYCLE SILO
PARTICULATE STORAGE BIN
10
TO LANDFILL
SLAKER PRODUCT TANK
SLURRY FEED TANK
H₂O
12
RECYCLE SLURRY TANK

Generic lime spray dryer process. Flow diagram.

500 MWe

0.7%S - 70% Removal

GENERIC LIME SPRAY DRYER PROCESS

MATERIAL BALANCE

	Stream No.	1	2	3	4	5
	Description	Coal to boiler	Combustion air to air heater	Combustion air to boiler	Gas to economizer	Gas to air heater
1	Total stream, lb/hr	489,700	5,119,000	4,419,000	4,897,000	4,897,000
2	scfm at 60°F		1,131,000	976,400	1,045,000	1,045,000
3	Temperature, °F		80	535	890	705
4	Pressure, psig					
5	gpm					
6	Specific gravity					
7	pH					
8	Undissolved solids, %					
9	Ash wt % (wet)	9.71				
10	Sulfur wt % (wet)	0.59				

	Stream No.	6	7	8	9	10
	Description	Gas to FGD system	Gas to spray dryer	Gas from spray dryer	Gas to stack[a]	Waste to landfill
1	Total stream, lb/hr	5,597,000	4,547,000	4,743,000	5,715,000	44,650
2	scfm at 60°F	1,200,000	975,000	1,020,000	1,250,000	
3	Temperature, °F	300	300	160	175	
4	Pressure, psig					
5	gpm					
6	Specific gravity					
7	pH					
8	Undissolved solids, %					
9						
10						

	Stream No.	11	12	13	14	15
	Description	Waste to recycle particulate silo	Makeup water to recycle slurry tank	Recycle slurry to spray dryer	Makeup lime to slaker	Makeup water to slaker
1	Total stream, lb/hr	55,450	83,150	138,600	3,661	11,350
2	scfm at 60°F					
3	Temperature, °F					
4	Pressure, psig					
5	gpm		166			23
6	Specific gravity					
7	pH					
8	Undissolved solids, %			40		
9						
10						

	Stream No.	16	17	18		
	Description	Grit to landfill	Lime slurry to spray dryer	Dilution water to spray dryer		
1	Total stream, lb/hr	366	14,650	19,890		
2	scfm at 60°F					
3	Temperature, °F			60		
4	Pressure, psig					
5	gpm			40		
6	Specific gravity					
7	pH					
8	Undissolved solids, %		22.5			
9						
10						

a. Includes air inleakage into the baghouse.

scfm = standard cubic feet per minute.

LIME DRY SCRUBBING FGD CAPITAL INVESTMENT[1]

	Capital Investment, 103$	
	0.7% S - 70% Removal	3.5% S - 90% Removal
Direct Investment		
Material Handling	1,634	4,639
Feed Prep	615	1,378
Gas Handling	9,471	10,481
SO_2 Absorption	7,088	8,713
Particulate Removal (Baghouse)	11,133	10,855
Particulate Handling & Recycle	1,392	636
Solids Disposal	444	674
Total Process Capital	31,777	37,376
Services, Utilities, Misc. (6% TPC)	1,907	2,243
Land Fill Construction	2,345	4,199
Total Direct Investment	36,029	43,818
Indirect Investment		
Engr. Design & Supv.	2,522	3,067
A & E	721	876
Construction Expense	5,765	7,011
Contractor Fees	1,801	2,191
Contingency	9,367	11,393
Total Fixed Investment	56,205	68,355
Other Capital Requirements		
Startup & Modification	5,621	6,836
Interest During Const.	8,768	10,663
Royalties	180	2,019
Land	720	1,320
Working Capital	1,927	2,795
Total Capital Investment	73,421	90,188
&/kwe	146.8	180.4

[1] Source: Tom Burnett, Economic Evaluation Section, TVA, Muscle Shoals, Ala., July 1980. These results are preliminary and are not approved by TVA or EPA.

Bases
1982 $
500 MWe Boiler

LIME DRY SCRUBBING FGD ANNUAL REVENUE REQUIREMENT[1]

		0.7% S - 70% Removal		3.5% S - 90% Removal	
Direct Costs	Unit Cost, $	Annual Quantity	Annual Cost $10^3$$	Annual Quantity	Annual Cost $10^3$$
Direct Costs					
Raw Materials					
Lime	$102/ton-0.7% S $ 75/ton-3.5% S	10,100 tons	1,030.2	86,100 tons	6,457.5
Conversion Costs					
Operating Labor & Supv					
FGD	$15/m-h	25,400 m-h	381.0	29,120 m-h	436.8
Solids Disposal	$21/m-h	14,560 m-h	305.8	20,800 m-h	436.8
Utilities					
Process Water	$0.14/kgal	78,600 kgal	11.0	134,600 kgal	18.8
Electricity	$0.037/kwh	39,405,000 kwh	1,458.0	41,603,000 kwh	1,539.3
Steam	$2.70/MBtu				371.0
Maintenance					
Labor & Material			2,091.7		2,503.1
Analyses	$21/m-h	4,160 m-h	87.4	4,160 m-h	87.4
Waste Disposal Operation	$0.15/ton	122,800 tons	18.4	280,800 tons	42.1
Total Conv. Costs			4,353.0		5,435.3
Total Direct Costs			5,383.5		11,892.8
Indirect Costs					
Overheads					
Plant & Admin.			1,730.6		2,103.7
First Year - O & M			7,114.1		13,996.5
Levelized Capital Charges (14.7% of TCI)			10,792.8		13,257.7
Total First Year Annual Revenue Requirement			17,906.9		27,254.2
Levelized First Year O & M (1.886 × First Year O & M)			13,417.1		26,397.4
Levelized Annual Revenue Requirement			24,209.9		39,655.1
First Year Annual Revenue Requirement, mills/Kwh			6.51		9.91
Levelized Annual Revenue Requirement, mills/Kwh			8.80		14.42

[1] Source: Tom Burnett, Economic Evaluation Section, TVA, Muscle Shoals, Ala., July, 1980. These results are preliminary and are not approved by TVA or EPA.

Bases
1984 $
500 MWe Boiler
0.63 Capacity Utilization Factor

LIME DRY SCRUBBING FGD
BARE EQUIPMENT COSTS & INSTALLATION FACTORS

	0.7% S - 70% Removal			3.5% S - 90% Removal		
	Material Cost 10^3\$, 1982	Installation Factor		Material Cost 10^3\$, 1982	Installation Factor	
Material Handling	333.3	4.90	4.25	825.0	5.62	5.17
Feed Preparation	195.7	3.14		399.4	4.06	
Gas Handling	2260.0	4.19		2260.8	4.64	
SO_2 Absorption (3 operator, 1 spare)	4324.0	1.64		5405.5	1.61	
Particulate Removal (Baghouse)	8262.0	1.35		8032.0	1.35	
Particulate Handling and Recycle	556.9	2.49		266.7 (no Recycle)	2.38	

Bases
- 1982 $
- 500 MWe Boiler

To obtain 1980$ cost multiply 1982$ costs by:

Material CECI $\frac{1980}{1982} = \frac{286.1}{333.7} = 0.857$

LIME DRY SCRUBBING FGD
250 & 1000 MWe Assumptions

Investment Scale Factors	Scale Factor
Material Handling	0.89
Feed Preparation	0.57
Gas Handling	0.68
SO_2 Absorption	0.65
Particulate Removal	1.0
Particulate Handling	0.71
Solids Disposal	1.0
Land Fill Construction	1.0

Operating Labor & Supv

250,500 & 1000 MWe dry scrubbing in same proportions as operating labor & supv. for the limestone cases.

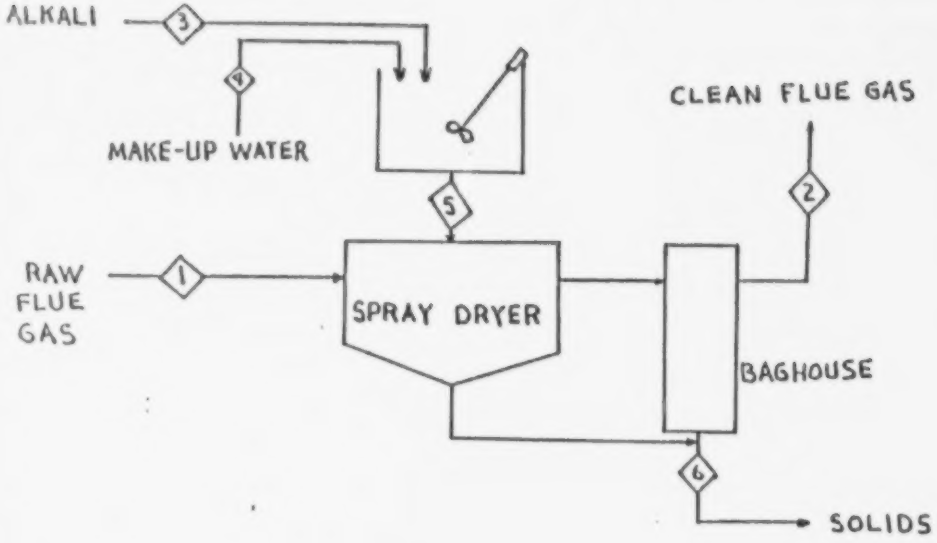
	Man-hours/year	
MWe	Wet Scrubbing	Dry Scrubbing
250	20810	18580
500	28450	25400
1000	38910	34740

APPENDIX E

INDUSTRIAL BOILER LIME DRY SCRUBBING FGD SYSTEM PREMISES

MATERIAL BALANCES

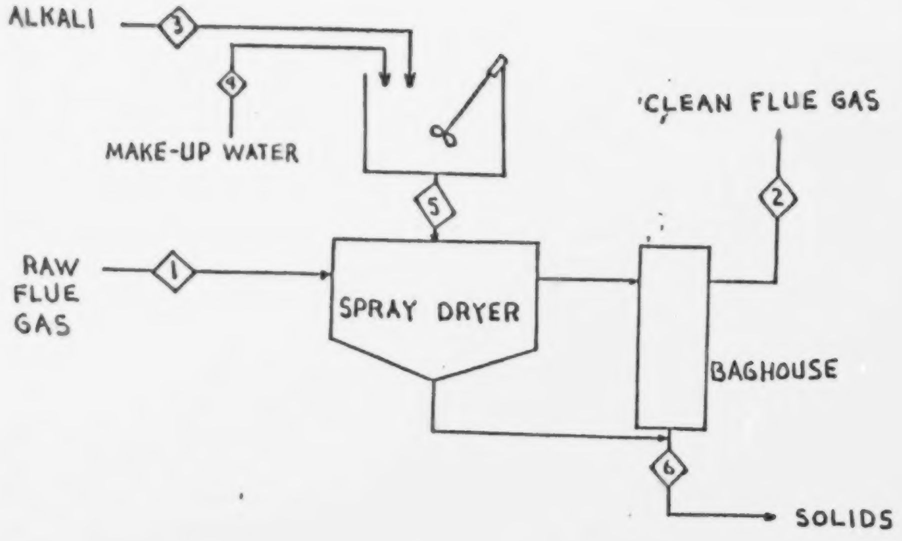
EQUIPMENT LISTS AND COSTS


ALKALI
3
4
MAKE-UP WATER
5
CLEAN FLUE GAS
2
RAW FLUE GAS
1
SPRAY DRYER
BAGHOUSE
6
SOLIDS

SPRAY DRYER FGD

Boiler size: 150 x 10^6 BTU/Hr.
Coal type: Western
SO_2 removal: 75%
Type alkali: Lime
Percent ash*: 5.4% (wt)
Percent sulfur*: 0.6% (wt)
*Wet Basis

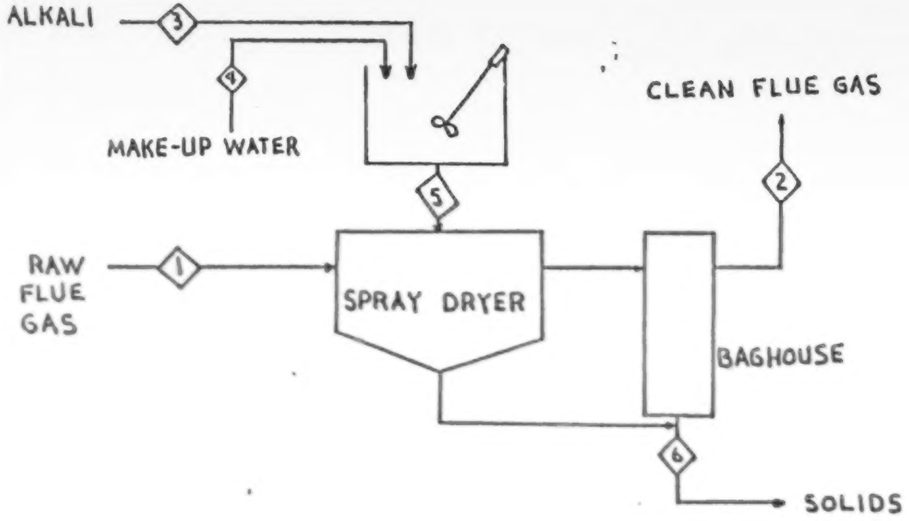
Stream Number / Description	1 Inlet Gas	2 Exit Gas	3 Alkali	4 Water	5 Slurry to Dryer	6 Solids
TOTAL FLOW RATE						
lb/hr	185,640	190,709	187	9688	9875	855
gpm				19.4	19.4	
Temp (°F)	350	175				
GAS FLOW RATE						
lb/hr	185,092	190,706				
lb/moles/hr	6382	6715				
ACFM	62,800	51,797				
SCFM	40,316	42,416				
LIQUID FLOW RATE						
lb/hr				9688	9688	
SOLID FLOW RATE						
lb/hr	548	3	187		187	855


ALKALI
③
MAKE-UP WATER
④
RAW FLUE GAS
①
⑤
SPRAY DRYER
BAGHOUSE
⑥
SOLIDS
CLEAN FLUE GAS
②

SPRAY DRYER FGD

Boiler size: 400 x 10^6 BTU/Hr.
Coal type: Western
SO_2 removal: 70%
Type alkali: Lime
Percent ash*: 5.4%(wt)
Percent sulfur*: 0.6%(wt)
*Wet basis

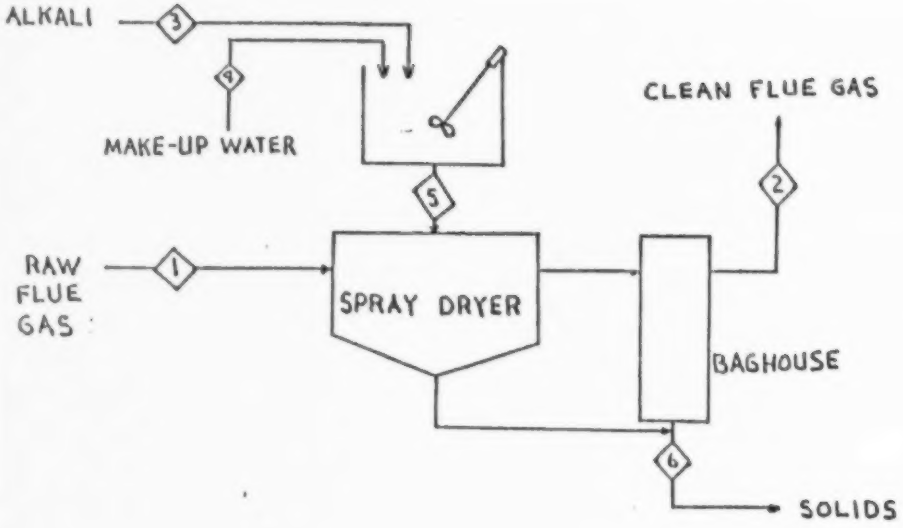
Stream Number & Description	1 Inlet Gas	2 Exit Gas	3 Alkali	4 Water	5 Slurry to Dryer	6 Solids
TOTAL FLOW RATE						
lb/hr	431,620	451,532	499	21,890	22,389	2781
gpm	—	—	—	43.8	43.8	—
Temp (°F)	350	175	—	—	—	—
GAS FLOW RATE						
lb/hr	429,820	451,523				
lb/moles/hr	14,820	16,031				
ACFM	146,000	123,800				
SCFM	88,680	95,918				
LIQUID FLOW RATE						
lb/hr				21,890	21,890	
SOLID FLOW RATE						
lb/hr	1800	9	499		499	2781


ALKALI
3
4
MAKE-UP WATER
5
RAW FLUE GAS
1
SPRAY DRYER
BAGHOUSE
CLEAN FLUE GAS
2
6
SOLIDS

SPRAY DRYER FGD

Boiler size: 75 x 10^6 BTU/Hr.
Coal type: Medium Sulfur
SO_2 removal: 70%
Type alkali: Lime
Percent ash*: 13.2%(wt)
Percent sulfur*: 2.3%(wt)
*Wet basis

Stream Number & Description	1 Inlet Gas	2 Exit Gas	3 Alkali	4 Water	5 Slurry to Dryer	6 Solids
TOTAL FLOW RATE						
lb/hr	91,691	96,359	261	4948	5209	675
gpm	—	—		9.9	9.9	
Temp (°F)	400	175				
GAS FLOW RATE						
lb/hr	91,503	96,358				
lb/moles/hr	3155	3427				
ACFM	33,000	26,467				
SCFM	18,879	20,507				
LIQUID FLOW RATE						
lb/hr				4948	4948	
SOLID FLOW RATE						
lb/hr						


ALKALI
3
4
MAKE-UP WATER
5
RAW FLUE GAS
1
SPRAY DRYER
CLEAN FLUE GAS
2
BAGHOUSE
6
SOLIDS

SPRAY DRYER FGD

Boiler size: 400 x 10^6 BTU/Hr.
Coal type: Medium Sulfur
SO_2 removal: 70%
Type alkali: Lime
Percent ash*: 13.2%(wt)
Percent sulfur*: 2.3%(wt)
*Wet basis

Stream Number / Description	1 Inlet Gas	2 Exit Gas	3 Alkali	4 Water	5 Slurry to Dryer	6 Solids
TOTAL FLOW RATE						
lb/hr	422,488	441,532	1389	22,690	24,079	5782
gpm	—	—	—	45.4	45.4	—
Temp (°F)	400	175	—	—	—	—
GAS FLOW RATE						
lb/hr	419,250	441,516				
lb/moles/hr	14,457	15,703				
ACFM	151,200	121,270				
SCFM	86,500	93,959				
LIQUID FLOW RATE						
lb/hr				22,690	22,690	
SOLID FLOW RATE						
lb/hr	3198	16	1389		1389	5782

EQUIPMENT LIST - PURCHASED PRICE
LIME DRY SCRUBBING FGD - INDUSTRIAL BOILERS

	44 MWt - 0.6% S - 70% Removal		118 MWt - 0.6% S - 70% Removal		22 MWt - 2.3% S - 70% Removal		118 MWt - 2.3% S - 70% Removal	
	Description	$	Description	$	Description	$	Description	$
Raw Material Handling								
Pneumatic Conveyor		3,394		3,394		3,394		3,394
Silo - 2 wk Capacity	63 k lbs	18,500	167.7 k lbs	36,000	87.7 k lbs	23,200	466.7 k lbs	72,000
Screw Feeder		1,193		1,193		1,193		1,193
Mix Tank - 5 mw		330		760		280		760
Mixer		270		520		260		520
Lime Slaker		16,000		17,300		16,500		18,800
Feed Pumps - 2		7,200	44 gpm	9,200	10 gpm	6,800	45 gpm	9,200
		46,900		68,380		51,640		105,930
Fans	62,800 acfm	29,000	146,000 acfm	54,000	33,000 acfm	18,000	151,200 acfm	55,000
SO_2 Scrubbing[1]								
Absorber, Circulator Tank (5 min)		230,000		337,200		170,800		349,200
Mixer, Circulation Pumps								
Solids Collection[2]								
Baghouse								
Equip.		359,750		812,700		193,200		840,650
Installation Costs		353,359		497,540		246,918		503,438
		713,109		1,310,240		440,138		1,344,088

[1] SO_2 Scrubbing = installed cost

[2] Installation costs = $- 1506523 + 168531 \ln \left[(\text{acfm}) \frac{2}{A/C} \right]$ Equipment cost = $8.34 \, (\text{acfm})^{0.966} \left(\frac{2}{A/C} \right)$

A/C = air/cloth = 2.0 fpm

APPENDIX F

DESCRIPTION OF TVA AND PEDCO ENVIRONMENTAL, INC. INVESTMENT/COST COMPONENTS

APPENDIX F

1.0 TVA INVESTMENT/COST COMPONENTS

1.1 Capital Investment

Capital investment estimates are based on an East Central location (Kentucky, Illinois, Indiana, Ohio, Michigan, and Wisconsin) and represent projects beginning in 1981 and ending in 1983. Capital cash flows for a standard project are assumed to be 25% the first year, 50% the second year, and 25% the third year of the project life. Capital costs for fixed assets are projected to mid-1982, which represents approximately the midpoint of the construction expenditure schedule.

Typically, capital estimates made by Emission Control Development Projects are either preliminary or definitive level estimates. Preliminary estimates are based on a process description, flow sheet, material balance, and equipment list. Piping, ductwork, and instrumentation are normally factored. The preliminary capital cost estimate is normally considered to have a -20% to +40% range of accuracy. Definitive estimates are based on the same items as a preliminary estimate plus a layout, instrument control diagram, and piping diagram. The definitive estimate is considered to have a -5% to +25% range of accuracy.

The total fixed capital investment includes direct capital costs for equipment, building, utilities, service facilities, raw material and byproduct storage, waste disposal facilities, engineering design and supervision, construction expense, contractors' fees, and contingency.

The total capital investment includes the total fixed capital investment plus allowances for startup and modifications, royalties, the cost of funds used during construction, plus the cost of land and working capital.

(1) Direct Capital Costs - Process

Direct capital costs cover installed process equipment, piping, insulation, transport lines, foundations, structural, electrical, instrumentation, raw material and byproduct storage, site preparation and excavation, buildings, roads and railroads, trucks, and earthmoving equipment.

Direct investments are prepared using standard estimation techniques and the average annual Chemical Engineering cost indexes and projections as shown in Table F-1.

The overtime premium for 7% overtime is included in the construction labor. Appropriate amounts for sales tax and for freight are included in the process capital costs.

(2) Direct Capital Costs - Utilities, Service and Miscellaneous Facilities

Necessary electrical substations, conduit, steam, process water, fire and service water, instrument air, chilled water, inert gas, and compressed air distribution facilities are included in the utilities investment.

These facilities are costed as increments to the facilities already required by the power plant. For existing units, a package boiler is used for all steam generation including reheat, since steam is assumed to be unavailable from the power plant cycle. Flue gas from the package boiler is added to the utility boiler flue gas before the scrubber.

Electrical switchyard locations are assumed to be approximately 200 yards from the control rooms. Control room location varies with each process, depending upon equipment size and configuration. Generation facilities for electricity are not included.

Service facilities such as maintenance shops, stores, communications, security, offices, and road and railroad facilities are estimated or allocated on the basis of process requirements.

TABLE F-1

Cost Indexes and Projections

Year	1975	1976	1977	1978	1979[a]	1980[a]	1981[a]	1982[a]	1983[a]	1984[a]
Plant	182.4	192.1	204.1	218.8	240.2	259.4	278.9	299.8	322.3	344.9
Material[b]	194.7	205.8	220.9	240.6	262.5	286.1	309.0	333.7	360.4	385.6
Labor[c]	168.6	174.2	178.2	185.9	209.7	226.5	244.6	264.2	285.3	305.3

a. TVA projections
b. Same as index in Chemical Engineering (10) for "equipment, machinery, supports."
c. Same as index in Chemical Engineering (10) for "construction labor."

Services, nonpower plant utilities, and miscellaneous will normally be in the range of 4% to 8% of the total process capital depending on the type of process.

(3) Indirect Capital Costs

Indirect capital costs cover engineering design and supervision, architect and engineering contractor costs, construction costs, contractor fees, and contingency. Construction facilities, which include costs for mobile equipment, temporary lighting, construction roads, raw water supply, construction safety and sanitary facilities, and other similar expenses incurred during construction are considered part of construction expenses and are charged to indirect capital investment.

Listed below are the ranges of indirect costs to be used depending upon the scope and complexity of design and construction involved in the process being studied.

	% of direct investment		
	Low	Base	High
Engineering design and supervision	6	7	8
Architect and engineering contractor	1	2	3
Construction expense	14	16	18
Contractor fees	4	5	6
Total	25	30	35

For comparative studies, a contingency of 20% is included since projects normally have a higher likelihood of exceeding rather than underrunning the capital estimate. While actual projects could properly have both project and process contingencies of varying amounts depending on the type and developmental maturity of the process, comparability among processes could be skewed by the use of different contingencies in the same study.

(4) Other Capital Requirements

Startup and modification allowances are estimated as 8% to 12% of the total fixed investment depending upon the complexities of the process being studied.

For proprietary processes, either actual royalty fees or 0.5% of the direct investment will be charged.

Cost of funds during construction is estimated to be 15.6% of the total fixed investment for each process. This factor is equivalent to the 10% weighted cost of capital with 25% of the construction expenditures in the first year, 50% the second year, and 25% the third year of the project construction schedule. Expenditures in a given year are assumed to be uniform over that year. Start-up costs are assumed to occur late enough in the project schedule that there are no charges for the use of money used to pay startup costs. For processes that have construction periods significantly different than the 3-year premise period, the cost of funds during construction are adjusted to the actual period required.

1.2 ANNUAL REVENUE REQUIREMENTS

Annual revenue requirements use 1984 costs and are based on 5500 hours of operation per year at full load for pollution control processes that are close-coupled with a utility boiler. Typical operating experiences are used as a basis.

(1) Direct Operating and Maintenance Costs

Direct costs include raw materials, labor, utilities, maintenance, and analytical costs. Unit costs for steam and electricity are based on the assumption that the required energy is purchased from another source. Unit costs ($/kW, mills/kWh) are calculated on the basis of net power output after the addition of the pollution control systems. Acutally the electrical usage by the pollution control equipment after the ESP will result in a derating of the utility plant for either a new or a retrofitted unit. To minimize iterative calculations, instead of derating the utility plant, the pollution control equipment (excluding ESP) will be charged with purchased electricity.

Maintenance costs are estimated to be 3% to 9% of the direct investment based on unit size and process complexity.

(2) Indirect Operating and Maintenance Costs

Indirect costs cover levelized annual capital charges and overheads.

The levelized annual capital charges consist of sinking fund factor, allowance for interim replacement, property taxes, insurance, weighted cost of capital, income tax, credits for accelerated depreciation, and investment credit. The levelized annual capital charge for a regulated utility is 14.7%.

Overheads consist of plant, administrative, and marketing expenses assumed to be as follows:

- Plant and administrative overhead = 60 % of conversion costs less utilities
- Marketing overhead is assigned as applicable for processes that have byproduct sales

The plant and administrative overheads include plant services such as safety, cafeteria, medical, plant protection, janitorial, purchasing personnel, general engineering (excluding maintenance), interplant communications and transportation, recreational facilities, and the expenses connected with top management activities. Fringe benefits such as retirement, vacation, dental and medical plans are included in the base wage rates.

Credit is given for byproduct sales where appropriate. First-year annual revenue requirements using levelized capital charges (14.7%) are calculated. In addition, levelized annual revenue requirements are calculated using a 10% discount factor, 6% inflation factor, and a 30-year economic life giving a 1.886 leveling factor.

2.0 PEDCo ENVIRONMENTAL, INC., INVESTMENT/COST COMPONENTS

Capital cost and annualized cost are estimated for each FGD system. The capital cost represents the initial investment necessary to install and commission the system. The annualized cost represents the cost of operating and maintaining the system and the charges needed to recover the capital investment, which are referred to as fixed costs or fixed charges.

2.1 Capital Costs

Capital costs consist of direct and indirect costs incurred up to the successful commissioning of the facility. Direct costs include the costs of various items of equipment and the labor and material required for installing these items and interconnecting the system. Indirect costs are expenditures for the overall facility that cannot be attributed to specific equipment; they include such items as freight, spares, engineering, contingency, etc.

Direct Costs

The "bought-out" cost of the equipment and the cost of installing it are considered direct costs. A bought-out cost of an equipment item is the purchase price paid to the equipment supplier on a free-on-board (f.o.b.) basis; this does not include the freight charges. Installation costs cover the interconnection of the system, which involves piping, electrical, and the other work needed to commission it. Also attributed to installation are the costs of foundations, supporting structures, enclosures, ducting, control panels, instrumentation, insulation, painting, and similar items. Costs for interconnecting various items of FGD equipment include site development, construction of access roads and walkways, and the establishment of rail, barge, or truck facilities. Finally, the cost of administrative facilities is considered a direct cost.

Various procedures are available for estimating direct costs. The PEDCo computer model uses the installation factor technique to estimate total direct costs. The bought-out cost of each item of equipment is multiplied by an individual installation factor to obtain the installed cost. This installed cost includes a proportional cost for interconnecting the equipment into the system. The installation factors are based on the complexity of the equipment and the cost of the material and labor required. The installed costs of all the equipment are added together to obtain the total direct cost of the facility.

Indirect Costs

The indirect costs of an FGD system include the following:

Interest: covers interest accrued on borrowed capital during construction.

Engineering costs: include administrative, process, project, and general costs; design and related functions for specifications; bid analysis; special studies; cost analysis; accounting; reports; purchasing ; procurement; travel expenses; living expenses; expediting; inspection; safety; communications, modeling; pilot plant studies; royalty payments during construction; training of plant personnel; field engineering; safety engineering; and consultant services.

Freight: includes delivery costs on FGD process and related equipment shipped f.o.b. from point of origin.

Offsite expenditures: include expenditures for powerhouse modifications, interruption to power generation, and service facilities added to the existing plant facilities.

Taxes: include sales, franchise, property, and excise taxes.

Spare parts: represent costs of items stocked to permit high process availability; such items include pumps, valves, controls, special piping and fittings, instruments, spray nozzles, and similar equipment.

Shakedown: includes costs associated with system startup.

Contractor's fee and expenses: include costs for field labor payroll, supervision field office, administrative personnel, construction offices, temporary roadways, railroad trackage, maintenance and welding shops, parking lot, communications, temporary piping, electrical, sanitary facilities, rental equipment, unloading and storage of materials, travel expenses, permits, licenses, taxes, insurance, overhead, legal liability, field testing of equipment, and labor relations.

Contingency costs: include costs resulting from malfunctions, equipment design alterations, and similar unforeseen sources.

Land cost: includes only the cost of the land required for sludge disposal. The cost of land for installing FGD equipment is accounted for in the installation factors.

All indirect cost components, except land cost, are obtained by multiplying the direct costs by an indirect cost factor. The land cost is based on land rate and the disposal area required.

2.2 Annual Revenue Requirements

The capital investment of a pollution control system is generally translated into annual fixed charges. These charges, along with the annual operating costs, represent the total revenue requirement of a particulate control system.

The annual fixed charges are classified under four cost components: depreciation, taxes, insurance, and capital costs. The component costs are summed to obtain the total fixed charges.

Depreciation: The value of the depreciation component is obtained by using a straight-line depreciation over the life period of the pollution control system. A 20-year life is assumed for depreciation purposes. The annual cost is calculated by dividing the total capital investment by the assumed years of life.

Annualized Costs

The annualized operating costs of an FGD system consist of the following:

Raw materials: include costs of lime for the FGD system and fixation chemicals.

Utilities: include costs of water for slurries, cooling, and cleaning; electricity for pumps, fans, valves, lighting controls, conveyors, and mixers; fuel for reheating flue gases; and steam for processing.

Operating Labor: includes costs of supervision and skilled and unskilled labor to operate, monitor, and control the FGD process.

Maintenance and repairs: include costs of manpower and materials to keep the unit operating efficiently. The function of maintenance is both preventative and corrective to keep outages to a minimum.

Overhead: represents business expenses that are not charged directly to a particular part of a process, but are allocated to it. Overhead costs include administrative, safety, engineering, legal, and medical services; payroll; employee benefits; recreation; and public relations.

The capital investment in an FGD system is generally translated into annual fixed charges. These charges, along with the annual operating cost, represent the total revenue requirement or annualized cost of a system. The annual fixed charges are calculated under four cost components: depreciation, taxes, insurance, and capital costs. The values for these components are obtained as follows:

Depreciation: calculated by using a sinking-fund method over the life period of the FGD system.

Taxes: calculated by multiplying the total capital cost by the input tax rate. The tax rate varies for different plants.

Insurance: calculated by multiplying the total capital cost by the insurance rate.

Capital charges: calculated by multiplying the total capital cost by the input interest rate. Capital charges represent the interest paid per year for the use of capital, and they vary according to interest rates.

The total annual fixed charges are obtained by adding the values of the above four components. The annualized cost or total annual revenue is the sum of the annual operating costs and the total annual fixed charges.

APPENDIX G

UTILITY BOILER LIME FGD SYSTEM COSTS

COMPARISON OF TVA'S OLD & NEW PREMISES

PEDCO ENVIRONMENTAL, INC., COSTS

APPENDIX G

In this Appendix, the TVA cost estimating procedures are described and compared for their "old" and "new" premises (see Section 4 for discussion). Costs are presented for a system based on the following:

500 MWe Boiler
Lime Wet Scrubbing
Approximately 90% SO_2 Removal

In addition, PEDCo Environmental, Inc., costs for a similar system are also presented.

OLD PREMISES
500 MW
LIME WET SCRUBBING

```
EXAMPLE CASE [redacted]                                      CASE 002

                    *** INPUTS ***

BOILER CHARACTERISTICS
------ ---------------

MEGAWATTS =   500.

BOILER HEAT RATE =  9000. BTU/KWH

EXCESS AIR =  33. PERCENT, INCLUDING LEAKAGE

HOT GAS TEMPERATURE = 300. DEG F

COAL ANALYSIS, WT % AS FIRED :

 C      H      O      N      S      CL    ASH    H2O
57.56  4.14   7.00   1.29   3.12   0.10  16.00  10.74

SULFUR OVERHEAD =  95.0 PERCENT

ASH OVERHEAD =  80.0 PERCENT

HEATING VALUE OF COAL = 10500. BTU/LB

                      EFFICIENCY,    EMISSION,
FLYASH REMOVAL             %         LBS/M BTU
------ -------        -----------    ---------

UPSTREAM OF SCRUBBER       98.5          0.18

WITHIN SCRUBBER            50.0          0.09

COST OF UPSTREAM FLYASH REMOVAL EXCLUDED


ALKALI
------

LIME :

        CAO           =  97.15 WT % DRY BASIS
        SOLUBLE MGO =     0.0
        INERTS        =   2.85
        MOISTURE CONTENT :   5.00 LB H2O/100 LBS DRY LIME

FLY ASH :

        SOLUBLE CAO =    0.0   WT %
        SOLUBLE MGO =    0.0
        INERTS        = 100.00


RAW MATERIAL HANDLING AREA
--- -------- -------- ----

NUMBER OF REDUNDANT ALKALI PREPARATION UNITS =     0
```

OLD PREMISES
500 MW
LIME WET SCRUBBING

```
SCRUBBER SYSTEM VARIABLES
-------- ------ ---------

NUMBER OF OPERATING SCRUBBING TRAINS =   6

NUMBER OF REDUNDANT SCRUBBING TRAINS =   0

NUMBER OF BEDS =   3

NUMBER OF GRIDS =   4

HEIGHT OF SPHERES PER BED =  5.0 INCHES

LIQUID-TO-GAS RATIO =  55. GAL/1000 ACF(SATD)

SCRUBBER GAS VELOCITY = 12.8 FT/SEC

INDUCED DRAFT SCRUBBER FAN OPTION

SCRUBBER PRESSURE = 14.7 PSIA

STOICHIOMETRY =  1.10 MOLE CAO ADDED AS LIME
                      PER MOLE (SO2+2HCL) ABSORBED

SCRUBBER INLET LIQUOR PH =  7.00

SO2 EMISSION LIMIT = 0.60 LB SO2/M BTU

ENTRAINMENT LEVEL = 0.10 WT %

EHT RESIDENCE TIME =  12.0 MIN

SO2 OXIDIZED IN SYSTEM =  30.0 PERCENT

SOLIDS IN RECIRCULATED SLURRY =  15.0 WT %


SOLIDS DISPOSAL SYSTEM
------ -------- ------

COST OF LAND =  3500.00 DOLLARS/ACRE

SOLIDS IN SYSTEM SLUDGE DISCHARGE =  60.0 WT %

MAXIMUM POND AREA =  9999. ACRES

MAXIMUM EXCAVATION =  25.00 FT

DISTANCE TO POND =  5280. FT

POND LINED WITH 12.0 INCHES CLAY


STEAM REHEATER (IN-LINE)
----- -------- ---------

SATURATED STEAM TEMPERATURE =  470. DEG F

HEAT OF VAPORIZATION OF STEAM =  751. BTU/LB

OUTLET FLUE GAS TEMPERATURE = 175. DEG F
```

OLD PREMISES
500 MW
LIME WET SCRUBBING

```
SUPERFICIAL GAS VELOCITY (FACE VELOCITY) =  25.0 FT/SEC

100.0000**************       42.1480    10500.0000
```

OLD PREMISES
500 MW
LIME WET SCRUBBING

```
EXAMPLE CASE OLD PREMSIS LIME                                              CASE 002

                    *** OUTPUTS ***

HOT GAS TO SCRUBBER
--- --- -- --------

          MOLE PERCENT      LB-MOLE/HR      LB/HR

CO2          12.315         0.2034E+05      0.9040E+06
HCL           0.007         0.1209E+02      0.4408E+03
SO2           0.238         0.3962E+03      0.2538E+05
O2            4.827         0.8051E+04      0.2576E+06
N2           73.869         0.1232E+06      0.3452E+07
H2O           8.745         0.1459E+05      0.2[illegible]28E+06

SO2 CONCENTRATION IN SCRUBBER INLET GAS = 2375. PPM
                                        = 5.64 LBS / MILLION BTU

FLYASH EMISSION =  0.18 LBS/MILLION BTU
                =  0.091 GRAINS/SCF (WET)  OR     823. LB/HR

     SOLUBLE CAO IN FLY ASH =      0. LB/HR
     SOLUBLE MGO IN FLY ASH =      0.

HOT GAS FLOW RATE =  .1054E+07 SCFM (60 DEG F, 14.7 PSIA)
                  =  .1540E+07 ACFM (300. DEG F, 14.7 PSIA)

CORRESPONDING COAL FIRING RATE =  .4286E+06 LB/HR

HOT GAS HUMIDITY =  0.057 LB H2O/LB DRY GAS

WET BULB TEMPERATURE = 129. DEG F


WET GAS FROM SCRUBBER
--- --- ---- --------

          MOLE PERCENT      LB-MOLE/HR      LB/HR

CO2          11.540         0.2050E+05      0.9024E+06
HCL           0.000         0.6045E+00      0.2204E+02
SO2           0.026         0.4215E+02      0.2700E+04
O2            4.501         0.7998E+04      0.2559E+06
N2           69.342         0.1232E+06      0.3452E+07
H2O          14.593         0.2593E+05      0.4671E+06

SO2 CONCENTRATION IN SCRUBBER OUTLET GAS =  237. PPM

FLYASH EMISSION =  0.09 LBS/MILLION BTU
                =  0.043 GRAINS/SCF (WET)  OR     411. LB/HR

TOTAL WATER PICKUP =  419.  GPM
            INCLUDING   10.2 GPM ENTRAINMENT

WET GAS FLOW RATE =  .1122E+07 SCFM (60 DEG F, 14.7 PSIA)
                  =  .1271E+07 ACFM (129. DEG F, 14.7 PSIA)

WET GAS SATURATION HUMIDITY =  0.101 LB H2O/LB DRY GAS
```

OLD PREMISES
500 MW
LIME WET SCRUBBING

```
FLUE GAS TO STACK
---- --- -- -----

        MOLE PERCENT     LB-MOLE/HR      LB/HR

CO2        11.521        0.2050E+05     0.9024E+06
HCL         0.000        0.6045E+00     0.2204E+02
SO2         0.024        0.4215E+02     0.2700E+04
O2          4.494        0.7998E+04     0.2559E+06
N2         69.233        0.1232E+06     0.3452E+07
H2O        14.728        0.2621E+05     0.4722E+06

CALCULATED SO2 REMOVAL EFFICIENCY =  89.4 %

SPECIFIED  SO2 EMISSION =   0.60 POUNDS PER MILLION BTU

CALCULATED SO2 CONCENTRATION IN STACK GAS =     237. PPM

FLYASH EMISSION =  0.09 LBS/MILLION BTU
                =  0.043 GRAINS/SCF (WET)  OR    411. LB/HR

STACK GAS FLOW RATE =  .1124E+07 SCFM (60 DEG F, 14.7 PSIA)
                    =  .1373E+07 ACFM (175. DEG F, 14.7 PSIA)


STEAM REHEATER (IN-LINE)
----- -------- ---------

SUPERFICIAL GAS VELOCITY (FACE VELOCITY) =  25.0 FT/SEC

SQUARE PIPE PITCH = 2 TIMES ACTUAL PIPE O.D.

SATURATED STEAM TEMPERATURE =  470. DEG F

OUTLET FLUE GAS TEMPERATURE = 175. DEG F

REQUIRED HEAT INPUT TO REHEATER = 0.5712E+08 BTU/HR

STEAM CONSUMPTION = 0.7606E+05 LBS/HR


                                HEAT TRANSFER
OUTSIDE PIPE   PRESSURE DROP,   COEFFICIENT,
DIAMETER, IN.  IN. H2O          BTU/HR FT2 DEG F
  1.00             0.62           0.2079E+02


               REHEATER         NUMBER OF
               OUTSIDE PIPE     PIPES PER     NUMBER OF
               AREA, SQ FT      BANK PER      BANKS (ROWS)
               PER TRAIN        TRAIN         PER TRAIN

INCONEL        0.1184E+04          87             3
CORTEN         0.9577E+03          87             3
TOTAL          0.2141E+04          87             6
```

OLD PREMISES
500 MW
LIME WET SCRUBBING

```
WATER BALANCE INPUTS
----- ------- ------

  RAINFALL(IN/YEAR)                    50.
  POND SEEPAGE(CM/SEC)*10**8           50.
  POND EVAPORATION(IN/YEAR)            32.


WATER BALANCE OUTPUTS
----- ------- -------

WATER AVAILABLE

  RAINFALL                            645. GPM           322187. LB/HR
  ALKALI                                2. GPM             1142. LB/HR
      TOTAL                           647. GPM           323329. LB/HR


WATER REQUIRED

  HUMIDIFICATION                      409. GPM           204351. LB/HR
  ENTRAINMENT                          10. GPM             5074. LB/HR
  DISPOSAL WATER                      163. GPM            81395. LB/HR
  HYDRATION WATER                      12. GPM             6027. LB/HR
  CLARIFIER EVAPORATION                 0. GPM                0. LB/HR
  POND EVAPORATION                    448. GPM           224072. LB/HR
  SEEPAGE                              80. GPM            40002. LB/HR

  TOTAL WATER REQUIRED               1122. GPM           560921. LB/HR

NET WATER REQUIRED                    475. GPM           237592. LB/HR
```

OLD PREMISES
500 MW
LIME WET SCRUBBING

```
SCRUBBER SYSTEM
------- ------

TOTAL NUMBER OF SCRUBBING TRAINS (OPERATING+REDUNDANT) =  4

SO2 REMOVAL =  89.4 PERCENT

PARTICULATE REMOVAL IN SCRUBBER SYSTEM =  50.0 PERCENT

TCA PRESSURE DROP ACROSS  3 BEDS =  8.6 IN. H2O

TOTAL SYSTEM PRESSURE DROP = 14.6 IN. H2O

OVERRIDE TOTAL SYSTEM PRESSURE DROP = 20.0 IN. H2O

SPECIFIED  LIQUID-TO-GAS-RATIO    =  55. GAL/1000 ACF(SATD)

LIME ADDITION = 0.2285E+05 LB/HR DRY LIME

SPECIFIED  LIME STOICHIOMETRY       =  1.10 MOLE CAO ADDED AS LIME
                                          PER MOLE (SO2+2HCL) ABSORBED

SOLUBLE CAO FROM FLY ASH =  0.0  MOLE PER MOLE (SO2+2HCL) ABSORBED

TOTAL SOLUBLE MGO        =  0.0  MOLE PER MOLE (SO2+2HCL) ABSORBED

TOTAL STOICHIOMETRY      =  1.10 MOLE SOLUBLE (CA+MG)
                                 PER MOLE (SO2+2HCL) ABSORBED

SCRUBBER INLET LIQUOR PH =  7.00

MAKE UP WATER =  475. GPM

CROSS-SECTIONAL AREA PER SCRUBBER =   424. SQ FT

SYSTEM SLUDGE DISCHARGE
------ ------ ---------                        SOLID   LIQUID
                                               COMP.   COMP.
SPECIES         LB-MOLE/HR   LB/HR             WT %    PPM

CASO3 .1/2 H2O  0.2478E+03   0.3199E+05        58.40
CASO4 .2H2O     0.1053E+03   0.1813E+05        33.09
CACO3           0.3597E+02   0.3601E+04         6.57
INSOLUBLES      ----------   0.1063E+04         1.94
H2O             0.4518E+04   0.8140E+05
CA++            0.6820E+01   0.2734E+03                3326.
MG++            0.0          0.0                          0.
SO3--           0.1354E+00   0.1084E+02                 132.
SO4--           0.9255E+00   0.8890E+02                1082.
CL-             0.1148E+02   0.4071E+03                4955.


TOTAL DISCHARGE FLOW RATE = 0.1370E+06 LB/HR
                          =   207.     GPM

TOTAL DISSOLVED SOLIDS IN DISCHARGE LIQUID =   9479. PPM

DISCHARGE LIQUID PH =  7.30
```

```
SCRUBBER SLURRY BLEED
-------- ------ -----

SPECIES             LB-MOLE/HR    LB/HR

CASO3 .1/2 H2O      0.2478E+03    0.3199E+05
CASO4 .2H2O         0.1053E+03    0.1813E+05
CACO3               0.3597E+02    0.3601E+04
INSOLUBLES          ----------    0.1063E+04
H2O                 0.1707E+05    0.3075E+06
CA++                0.2576E+02    0.1033E+04
MG++                0.0           0.0
SO3--               0.5115E+00    0.4095E+02
SO4--               0.3496E+01    0.3358E+03
CL-                 0.4339E+02    0.1538E+04
AD=                 0.0           0.0

TOTAL FLOW RATE = 0.3652E+06 LB/HR
                =     663.    GPM


TOTAL SUPERNATE RETURN
----- --------- ------

SPECIES             LB-MOLE/HR    LB/HR

H2O                 0.1574E+05    0.2837E+06
CA++                0.2377E+02    0.9526E+03
MG++                0.0           0.0
SO3--               0.4719E+00    0.3778E+02
SO4--               0.3225E+01    0.3098E+03
CL-                 0.4002E+02    0.1419E+04
AD=                 0.0           0.0

TOTAL FLOW RATE = 0.2864E+06 LB/HR
                =     573.    GPM


SUPERNATE TO LIME SLAKER
--------- -- ---- ------

SPECIES             LB-MOLE/HR    LB/HR

H2O                 0.6969E+04    0.1256E+06
CA++                0.1052E+02    0.4216E+03
MG++                0.0           0.0
SO3--               0.2089E+00    0.1672E+02
SO4--               0.1428E+01    0.1371E+03
CL-                 0.1772E+02    0.6280E+03
AD=                 0.0           0.0

TOTAL FLOW RATE = 0.1268E+06 LB/HR
                =     254.    GPM


LIME SLURRY FEED
---- ------ ----

SPECIES             LB-MOLE/HR    LB/HR

CASO3 .1/2 H2O      0.0           0.0
CASO4 .2H2O         0.5150E-01    0.8863E+01
CA(OH)2             0.3950E+03    0.2927E+05
```

OLD PREMISES
500 MW
LIME WET SCRUBBING

```
SOLUBLE MGO 0.0           0.0
INSOLUBLES         ----------    0.6512E+03
H2O                0,6669E+04    0.1202E+06
CA++               0,1124E+02    0.4505E+03
MG++               0,0           0,0
SO3--              0,2089E+00    0.1672E+02
SO4--              0,1376E+01    0.1322E+03
CL-                0,1772E+02    0,6280E+03
AD=                0,0           0,0

TOTAL FLOW RATE = 0,1509E+06 LB/HR
                =     268.    GPM


SUPERNATE RETURN TO SCRUBBER OR EHT
--------- ------ -- -------- -- ---

SPECIES            LB-MOLE/HR    LB/HR

H2O                0,8776E+04    0.1581E+06
CA++               0,1325E+02    0,5310E+03
MG++               0,0           0,0
SO3--              0,2630E+00    0,2106E+02
SO4--              0,1798E+01    0.1727E+03
CL-                0,2231E+02    0,7909E+03
AD=                0,0           0,0

TOTAL FLOW RATE = 0,1596E+06 LB/HR
                =     319.    GPM


RECYCLE SLURRY TO SCRUBBER
------- ------ -- --------

SPECIES            LB-MOLE/HR    LB/HR

CASO3 .1/2 H2O     0,2613E+05    0,3373E+07
CASO4 .2H2O        0,1110E+05    0.1911E+07
CACO3              0,3792E+04    0,3796E+06
INSOLUBLES         ----------    0.1120E+06
H2O                0,1799E+07    0,3242E+08
CA++               0,2716E+04    0.1089E+06
MG++               0,0           0,0
SO3--              0,5393E+02    0.4317E+04
SO4--              0,3686E+03    0,3541E+05
CL-                0,4574E+04    0.1622E+06
AD=                0,0           0,0

TOTAL FLOW RATE = 0,3850E+08 LB/HR
                =   69931.    GPM
```

OLD PREMISES
500 MW
LIME WET SCRUBBING

```
FLUE GAS COOLING SLURRY
---- --- ------- ------

SPECIES            LB-MOLE/HR    LB/HR

CASO3 .1/2 H2O     0.1900E+04    0.2453E+06
CASO4 .2H2O        0.8076E+03    0.1390E+06
CACO3              0.2758E+03    0.2761E+05
INSOLUBLES         --- ------    0.8147E+04
H2O                0.1309E+06    0.2358E+07
CA++               0.1975E+03    0.7918E+04
MG++               0.0           0.0
SO3--              0.3922E+01    0.3140E+03
SO4--              0.2681E+02    0.2575E+04
CL-                0.3327E+03    0.1179E+05
AD=                0.0           0.0

TOTAL FLOW RATE = 0.2800E+07 LB/HR
                =   5086.    GPM
```

OLD PREMISES
500 MW
LIME WET SCRUBBING

```
                      POND DESIGN
                      ---- ------

      OPTIMIZED TO MINIMIZE TOTAL COST PLUS OVERHEAD


    POND DIMENSIONS
    ---- ----------

    DEPTH OF POND                   20.49 FT
    DEPTH OF EXCAVATION              3.95 FT
    LENGTH OF POND PERIMETER       13269.   FT
    LENGTH OF DIVIDER               2409.   FT
    LENGTH PERIMETER FENCE         14235.   FT

    AREA OF BOTTOM                  1079.   THOUSAND YD2
    AREA OF INSIDE WALLS             129.   THOUSAND YD2
    AREA OF OUTSIDE WALLS             94.   THOUSAND YD2
    AREA OF RECLAIM STORAGE           96.   THOUSAND YD2
    AREA OF POND                    1208.   THOUSAND YD2
    AREA OF POND SITE               1504.   THOUSAND YD2
    AREA OF POND SITE                311.   ACRES

    VOLUME OF EXCAVATION            1575.   THOUSAND YD3
    VOLUME OF RECLAIM STORAGE        688.   THOUSAND YD3
    VOLUME OF SLUDGE TO BE          7826.   THOUSAND YD3
    DISPOSED OVER LIFE OF PLANT     4851.   ACRE FT


    POND COSTS (THOUSANDS OF DOLLARS)
    ---- ----- ---------- -- --------

                                    LABOR    MATERIAL    TOTAL
                                    -----    --------    -----

    CLEARING LAND                    503.                 503.
    EXCAVATION                      3913.                3913.
    DIKE CONSTRUCTION               1917.                1917.
    LINING( 12. IN. CLAY)           1007.                1007.
    SODDING DIKE WALLS                82.        53.      135.
    ROAD CONSTRUCTION                 38.        11.       49.
    PERIMETER COSTS, FENCE+           71.       142.      214.
    RECLAIMATION EXPENSE             830.                 830.
    MONITOR WELLS                      4.         4.        8.
    ----------------------------------------------------------
    POND CONSTRUCTION               8366.       211.     8577.
    LAND COST                                            1087.
    ----------------------------------------------------------
    POND SITE                                            9664.
    OVERHEAD                                             5832.
    ----------------------------------------------------------
    TOTAL                                               15496.
```

OLD PREMISES
500 MW
LIME WET SCRUBBING

```
      EXAMPLE CASE OLD PREMSIS LINE                                   CASE 002

                        PARTICULATE REMOVAL INVESTMENT AND OPERATING COST
                                                  PARTICULATE EMISSION REGULATION (LB ASH/MILLION BTU):   0.18
 WPSUL CONTENT (%):          3.12                 FLUE GAS TEMPERATURE (COLD) (F):                     300.0
 ASH CONTENT (%):           16.00                 FLUE GAS TEMPERATURE (HOT) (F):                      700.0
 BTU RATING:                10500                 COST OF ELECTRICITY ($/KWHR):                         0.03
 BOILER TYPE:               DRY PULVERIZED COAL   COST OF STEAM ($/THOUSAND LB):                        2.00
 NO. OF SCRUBBERS:              4                 FIRST YEAR CAPITAL CHARGE FACTOR:                     0.217
 SCRUBBER VELOCITY (FT/M):  750.0                 BAGHOUSE RATIO (OPER. SQ.FT./ACTUAL SQ.FT.):          0.80
 PLANT SIZE (MW):             500                 BAG COST ($/SQ.FT.):                                  0.70
 OPERATING HRS/YR:           7000                 BAG LIFE(YEARS):                                     3.00
 PUMPING RATE (GAL/1000 ACF): 20.00               FLUE GAS REHEAT TEMPERATURE (F):                     175.
 SCA RATIO:                 1.100                 CHEMICAL ENGINEERING PLANT INDEX:                    265.0
   (ACTUAL SQ.FT./CALC. SQ.FT.)



                                   ELECTROSTATIC PRECIPITATORS

                                            COLD          HOT          BAGHOUSE FABRIC FILTERS     SCRUBBERS

 REQUIRED REMOVAL EFFICIENCY (%):          98.50         98.50                98.50                  98.50
 DRIFT VELOCITY (FT/M):                    25.78         20.00
 SPECIFIC COLLECTION AREA (SQ.FT./ACFM):  179.17        230.98
 COLLECTION AREA (SQ.FT.):              275903.4      562883.0             271327.0
 TOTAL CORONA POWER (KW):                  370.5         565.5
 AUXILIARY POWER (KW):                     226.4         479.6                461.5
 FAN POWER (KW):                           241.0         367.8               1204.9                 2633.2
 PUMP POWER (KW):                                                                                   2982.6
 TOTAL POWER (KW):                         837.9        1412.9               1666.3                 5615.8
 OPERATING AIR/CLOTH RATIO:                                                     3.4
 INSTALLED AIR/CLOTH RATIO:                                                     2.7
 REQUIRED PRESSURE DROP (INCHES):            1.0           1.0                  5.0                   10.9
 DIAMETER (FEET):                                                                                       29
 REQUIRED REHEAT (BTU/HR):                                                                      38460416.0
 STEAM SUPPLY/YR (THOUSAND LB):                                                                   456247.6
 INSTALLED COST (1979 DOLLARS):         $ 4109471     $ 7262089           $ 11539158            $ 21061472
 FIRST YEAR CAPITALIZED COST:           $  891892     $ 1576116           $  2504381            $  4571041
 ANNUAL POWER COST:                     $  170092     $  288816           $   338268            $  1140000
 ANNUAL OPERATING AND
  MAINTENANCE COST (1979 DOLLARS):      $   86097     $  122523           $    70773            $  1105203
 REPLACEMENT COST (1979 DOLLARS):                                         $   176948
 ANNUAL REHEAT COST:                                                                            $   912493



 TOTAL ANNUAL COST:                     $ 1146084     $ 1985458           $  3088370            $  7728741
 ANNUALIZED COST OF POWER(MILLS/KWHR):      0.33          0.57                 0.88                   2.21
```

OLD PREMISES
500 MW
LIME WET SCRUBBING

RAW MATERIAL HANDLING AND PREPARATION

ITEM	DESCRIPTION	NO.	MATERIAL	LABOR
CONVEYOR FROM CALCINATION PLANT	1500FT HORIZONTAL, 30HP	1	177763.	31269.
STORAGE SILO ELEVATOR	126.FT HIGH, 50 HP	1	33720.	3727.
CONCRETE STORAGE SILO	137084.FT3/48.8FT DIA , 73.2FT STRAIGHT SIDE STORAGE HT	1	152068.	311874.
STORAGE SILO HOPPER BOTTOM	60 DEGREE, CS	1	19116.	12630.
RECLAIM VIBRATING FEEDER	3.5HP	1	3270.	326.
RECLAIM BELT CONVEYOR	126.FT HORIZONTAL, 5HP	1	22116.	2811.
FEED BIN ELEVATOR	50FT HIGH, 50HP	1	60871.	1836.
FEED BIN	10FT DIA, 15FT STRAIGHT SIDE HT, COVERED, CS	2	8882.	5509.
BIN VIBRATING FEEDER	3.5HP	2	17638.	2160.
BIN WEIGH FEEDER	18FT, 12IN SCREW, 1HP	2	8937.	1296.
SLAKER	6.TPH, 10.HP	2	100721.	8651.
SLAKER PRODUCT TANK		2	8828.	6913.
SLAKER PRODUCT TANK AGITATOR	10HP	2	13079.	3024.
LIME SYSTEM DUST COLLECTORS	POLYPROPYLENE BAG TYPE 2200 CFM,7.5HP	4	26594.	9503.
SLAKER PRODUCT TANK SLURRY PUMPS	134.GPM, 60FT HEAD, 4.HP, 2 OPERATING AND 1 SPARES	3	10173.	2887.
SLURRY FEED TANK	141462.GAL, 28.9FT DIA, 28.9FT HT, FLAKEGLASS-LINED CS	1	30915.	24679.
SLURRY FEED TANK AGITATOR	51.HP	1	49079.	3891.
SLURRY FEED TANK PUMPS	67.GPM, 60 FT HEAD, 2.HP, 4 OPERATING AND 2 SPARE	6	14671.	4536.
			----------	----------
TOTAL EQUIPMENT COST			757445.	437522.

OLD PREMISES
500 MW
LIME WET SCRUBBING

SCRUBBING

ITEM	DESCRIPTION	NO.	MATERIAL	LABOR
I.D. FANS	20.0IN H2O, WITH 1440. HP MOTOR AND DRIVE	4	3341278.	46644.
SHELL			993143.	
RUBBER LINING			973846.	
MIST ELIMINATOR			195856.	
SLURRY HEADER AND NOZZLES			239685.	
GRIDS			622604.	
SPHERES			578629.	
TOTAL TCA SCRUBBER COSTS		4	3403560.	241532.
REHEATERS		4	1581827.	95923.
SOOTBLOWERS		48	202286.	120973.
EFFLUENT HOLD TANK	230772.GAL, 34.0FT DIA, 34.0FT HT, FLAKEGLASS-LINED CS	4	196372.	153322.
EFFLUENT HOLD TANK AGITATOR	63.HP	4	261888.	83051.
COOLING SPRAY PUMPS	1271.GPM 100FT HEAD, 39.HP, 4 OPERATING AND 4 SPARE	8	69872.	20886.
ABSORBER RECYCLE PUMPS	8741.GPM, 100FT HEAD, 405.HP, 8 OPERATING AND 4 SPARE	12	662111.	71710.
MAKEUP WATER PUMPS	2543.GPM, 200.FT HEAD, 214.HP, 1 OPERATING AND 1 SPARE	2	22912.	2498.
			---------	---------
TOTAL EQUIPMENT COST			9682105.	835837.

OLD PREMISES
500 MW
LIME WET SCRUBBING

WASTE DISPOSAL

ITEM	DESCRIPTION	NO.	MATERIAL	LABOR
ABSORBER BLEED RECEIVING TANK	57632,GAL, 17.0FT DIA, 34.0FT HT, FLAKGLASS-LINED CS	1	19846.	15617.
ABSORBER BLEED TANK AGITATOR	36,HP	1	22256.	1764.
POND FEED SLURRY PUMPS	663,GPM, 130,FT HEAD, 40,HP, 1 OPERATING AND 1 SPARE	2	14993.	3873.
POND SUPERNATE PUMPS	573,GPM, 192,FT HEAD, 46,HP, 1 OPERATING AND 1 SPARE	2	10874.	1185.
			----------	----------
TOTAL EQUIPMENT COST			67969.	22439.

OLD PREMISES
500 MW
Lime Wet Scrubbing

LIME SLURRY PROCESS -- BASIS: 500 MW UNIT, 1981 STARTUP

PROJECTED CAPITAL INVESTMENT REQUIREMENTS - EXAMPLE CASE OLD PREMSIS LIME

CASE 002

	INVESTMENT, THOUSANDS OF 1980 DOLLARS				DISTRIBUTION
	RAW MATERIAL HANDLING AND PREPARATION	SCRUBBING	WASTE DISPOSAL	TOTAL	PERCENT OF DIRECT INVESTMENT
EQUIPMENT					
MATERIAL	757.	9682.	68.	10507.	31.3
LABOR	438.	836.	22.	1296.	3.9
PIPING					
MATERIAL	446.	2553.	847.	3845.	11.5
LABOR	210.	512.	282.	1004.	3.0
DUCTWORK					
MATERIAL	0.	1718.	0.	1718.	5.1
LABOR	0.	1385.	0.	1385.	4.1
FOUNDATIONS					
MATERIAL	64.	112.	17.	192.	0.6
LABOR	129.	233.	34.	396.	1.2
POND CONSTRUCTION	0.	0.	8577.	8577.	25.6
STRUCTURAL					
MATERIAL	94.	222.	2.	318.	0.9
LABOR	80.	373.	3.	456.	1.4
ELECTRICAL					
MATERIAL	106.	538.	126.	770.	2.3
LABOR	226.	1024.	265.	1514.	4.5
INSTRUMENTATION					
MATERIAL	93.	506.	9.	608.	1.8
LABOR	13.	82.	8.	104.	0.3
BUILDINGS					
MATERIAL	0.	0.	0.	0.	0.0
LABOR	0.	0.	0.	0.	0.0
SERVICES AND MISCELLANEOUS	70.	520.	270.	860.	2.6
SUBTOTAL DIRECT INVESTMENT	2724.	20295.	10529.	33549.	100.0
ENGINEERING DESIGN AND SUPERVISION	245.	1827.	948.	3019.	9.0
CONSTRUCTION EXPENSES	436.	3247.	1685.	5368.	16.0
CONTRACTOR FEES	136.	1015.	526.	1677.	5.0
CONTINGENCY	272.	2030.	1053.	3355.	10.0
SUBTOTAL FIXED INVESTMENT	3814.	28414.	14741.	46968.	140.0
ALLOWANCE FOR STARTUP AND MODIFICATIONS	305.	2273.	1179.	3757.	11.2
INTEREST DURING CONSTRUCTION	458.	3410.	1769.	5636.	16.8
SUBTOTAL CAPITAL INVESTMENT	4577.	34096.	17689.	56362.	168.0
LAND	10.	2.	1096.	1107.	3.3
WORKING CAPITAL	128.	953.	495.	1576.	4.7
TOTAL CAPITAL INVESTMENT	4714.	35052.	19279.	59045.	176.0

OLD PREMISES
500 MW
Lime Wet Scrubbing

```
      LIME SLURRY PROCESS -- BASIS:  500 MW UNIT, 1981 STARTUP
 PROJECTED LIFETIME REVENUE REQUIREMENTS - EXAMPLE CASE OLD PREMSIS LIME                                      CASE 002
                                                  TOTAL CAPITAL INVESTMENT:  $   59045000
                                                                                   ADJUSTED GROSS
                                                  SULFUR        BYPRODUCT          ANNUAL REVENUE
                                                  REMOVED         RATE,       SLUDGE      REQUIREMENT   TOTAL       NET ANNUAL  CUMULATIVE
 YEARS ANNUAL  POWER UNIT   POWER UNIT              BY          EQUIVALENT   FIXATION FEE  EXCLUDING    ANNUAL      INCREASE   NET INCREASE
 AFTER OPERA-     HEAT         FUEL             POLLUTION       TONS/YEAR       $/TON        SLUDGE      SLUDGE      IN TOTAL     IN TOTAL
 POWER TION,  REQUIREMENT, CONSUMPTION,          CONTROL                                   FIXATION    FIXATION     REVENUE      REVENUE
 UNIT  KW-HR  MILLION BTU   TONS COAL            PROCESS,          DRY            DRY        COST,       COST,    REQUIREMENT, REQUIREMENT,
 START  /KW      /YEAR        /YEAR             TONS/YEAR        SLUDGE          SLUDGE     $/YEAR      $/YEAR        $            $
 ---------------------------------------------------------------------------------------------------------------------------------------
   1    7000   31500000      1500000               39700          191700           0.0      23061800        0      23061800     23061800
   2    7000   31500000      1500000               39700          191700           0.0      23359000        0      23359000     46420800
   3    7000   31500000      1500000               39700          191700           0.0      23692900        0      23692900     70113700
   4    7000   31500000      1500000               39700          191700           0.0      24066500        0      24066500     94180200
   5    7000   31500000      1500000               39700          191700           0.0      24482100        0      24482100    118662300
   6    7000   31500000      1500000               39700          191700           0.0      24942100        0      24942100    143604400
   7    7000   31500000      1500000               39700          191700           0.0      25449100        0      25449100    169053500
   8    7000   31500000      1500000               39700          191700           0.0      26005500        0      26005500    195059000
   9    7000   31500000      1500000               39700          191700           0.0      26614800        0      26614800    221673800
  10    7000   31500000      1500000               39700          191700           0.0      27280300        0      27280300    248954100
 ---------------------------------------------------------------------------------------------------------------------------------------
  11    5000   22500000      1071400               28400          137000           0.0      23553300        0      23553300    272507400
  12    5000   22500000      1071400               28400          137000           0.0      24073700        0      24073700    296581100
  13    5000   22500000      1071400               28400          137000           0.0      24644800        0      24644800    321225900
  14    5000   22500000      1071400               28400          137000           0.0      25269400        0      25269400    346495300
  15    5000   22500000      1071400               28400          137000           0.0      25951000        0      25951000    372446300
  16    3500   15750000       750000               19800           95900           0.0      22010600        0      22010600    394456900
  17    3500   15750000       750000               19800           95900           0.0      22535300        0      22535300    416992200
  18    3500   15750000       750000               19800           95900           0.0      23111200        0      23111200    440103400
  19    3500   15750000       750000               19800           95900           0.0      23740600        0      23740600    463844000
  20    3500   15750000       750000               19800           95900           0.0      24427400        0      24427400    488271400
 ---------------------------------------------------------------------------------------------------------------------------------------
  21    1500    6750000       321400                8500           41100           0.0      16064800        0      16064800    504336200
  22    1500    6750000       321400                8500           41100           0.0      16329900        0      16329900    520666100
  23    1500    6750000       321400                8500           41100           0.0      16630100        0      16630100    537296200
  24    1500    6750000       321400                8500           41100           0.0      16967700        0      16967700    554263900
  25    1500    6750000       321400                8500           41100           0.0      17345100        0      17345100    571609000
  26    1500    6750000       321400                8500           41100           0.0      17764600        0      17764600    589373600
  27    1500    6750000       321400                8500           41100           0.0      18228300        0      18228300    607601900
  28    1500    6750000       321400                8500           41100           0.0      18739600        0      18739600    626341500
  29    1500    6750000       321400                8500           41100           0.0      19300800        0      19300800    645642300
  30    1500    6750000       321400                8500           41100           0.0      19915100        0      19915100    665557400
 ---------------------------------------------------------------------------------------------------------------------------------------

 TOT  127500  573750000     27321000              723000         3492500                   665557400        0     665557400
    LIFETIME AVERAGE INCREASE IN UNIT REVENUE REQUIREMENT
                            DOLLARS PER TON OF COAL BURNED                                     24.36      0.0         24.36
                            MILLS PER KILOWATT-HOUR                                            10.44      0.0         10.44
                            CENTS PER MILLION BTU HEAT INPUT                                  116.00      0.0        116.00
                            DOLLARS PER TON OF SULFUR REMOVED                                 920.55      0.0        920.55
 REVENUE REQUIREMENT DISCOUNTED AT  11.6% TO INITIAL YEAR, DOLLARS                         197778300        0     197778300
    LEVELIZED INCREASE IN UNIT REVENUE REQUIREMENT EQUIVALENT TO DISCOUNTED REQUIREMENT OVER LIFE OF POWER UNIT
                            DOLLARS PER TON OF COAL BURNED                                     18.57      0.0         18.57
                            MILLS PER KILOWATT-HOUR                                             7.96      0.0          7.96
                            CENTS PER MILLION BTU HEAT INPUT                                   88.44      0.0         88.44
                            DOLLARS PER TON OF SULFUR REMOVED                                 701.59      0.0        701.59
 UNIT COSTS INFLATED AT   6.00% PER YEAR
```

```
                                                              OLD PREMISES
    LIME SLURRY PROCESS -- BASIS:  500 MW UNIT, 1981 STARTUP  500 MW
                                                              Lime Wet Scrubbing
 PROJECTED REVENUE REQUIREMENTS - EXAMPLE CASE OLD PREMSIS LIME                   CASE 002

                            DISPLAY SHEET FOR YEAR=     1
                           ANNUAL OPERATION KW-HR/KW =  7000

                  27,39 TONS PER HOUR                    DRY                SLUDGE
                       TOTAL CAPITAL INVESTMENT       59045000                 TOTAL
                                                                              ANNUAL
                                         ANNUAL QUANTITY      UNIT COST,$     COST,$
                                         ---------------      -----------     ------
      DIRECT COSTS
      ------------
        RAW MATERIAL
        ------------
          LIME                                80.0 K TONS       40.00/TON       3198600
                                                                             ----------
             SUBTOTAL RAW MATERIAL                                              3198600

        CONVERSION COSTS
        ----------------
          OPERATING LABOR AND
            SUPERVISION                     34610.0 MAN-HR    12,50/MAN-HR       432600
          UTILITIES
            STEAM                          532390.0 K LB       2,00/K LB        1064800
            PROCESS WATER                  199660.0 K GAL      0.12/K GAL         24000
            ELECTRICITY                  53578740.0 KWH        0,029/KWH        1553800
          MAINTENANCE
            LABOR AND MATERIAL                                                  2255100
          ANALYSES                           5580.0 HR        17,00/HR            94800
                                                                             ----------
             SUBTOTAL CONVERSION COSTS                                          5425100

             SUBTOTAL DIRECT COSTS                                              8623700

      INDIRECT COSTS
      --------------
        DEPRECIATION                                                            1878700
        COST OF CAPITAL AND TAXES, 17,20% OF UNDEPRECIATED INVESTMENT          10155800
        INSURANCE & INTERIM REPLACEMENTS,  1,17% OF TOTAL CAPITAL INVESTMENT     690800
        OVERHEAD
          PLANT,  60,0% OF CONVERSION COSTS LESS UTILITIES                      1669500
          ADMINISTRATIVE, RESEARCH, AND SERVICE,
            10,0% OF OPERATING LABOR AND SUPERVISION                              43300
                                                                             ----------
             SUBTOTAL INDIRECT COSTS                                           14438100

             TOTAL ANNUAL REVENUE REQUIREMENT                                  23061800
                                                                             ----------

             EQUIVALENT UNIT REVENUE REQUIREMENT, MILLS/KWH                        6,59
---------------------------------------------------------------------------------------------------
        HEAT RATE    9000, BTU/KWH     -    HEAT VALUE OF COAL     10500 BTU/LB    -    COAL RATE   1500000 TONS/YR
```

NEW PREMISES
500 MW
LIME WET SCRUBBING

```
EXAMPLE CASE [redacted]                                      CASE 004

                    *** INPUTS ***

BOILER CHARACTERISTICS
------ ---------------

MEGAWATTS =   500.

BOILER HEAT RATE =  9500. BTU/KWH

EXCESS AIR =  39. PERCENT, INCLUDING LEAKAGE

HOT GAS TEMPERATURE = 300. DEG F

COAL ANALYSIS, WT % AS FIRED :

  C      H      O      N      S      CL    ASH    H2O
66.70  3.80   5.00   1.30   3.36   0.10  15.10   6.00

SULFUR OVERHEAD =  92.0 PERCENT

ASH OVERHEAD =  80.0 PERCENT

HEATING VALUE OF COAL = 11700. BTU/LB

                          EFFICIENCY,    EMISSION,
FLYASH REMOVAL                %          LBS/M BTU
------ -------            -----------    ---------

UPSTREAM OF SCRUBBER         99.7          0.03

WITHIN SCRUBBER              50.0          0.02

COST OF UPSTREAM FLYASH REMOVAL EXCLUDED


ALKALI
------

LIME :

        CAO          =  97.15 WT % DRY BASIS
        SOLUBLE MGO =   0.0
        INERTS       =   2.85
        MOISTURE CONTENT :   5.00 LB H2O/100 LBS DRY LIME

FLY ASH :

        SOLUBLE CAO =   0.0  WT %
        SOLUBLE MGO =   0.0
        INERTS       = 100.00


RAW MATERIAL HANDLING AREA
--- -------- -------- ----

NUMBER OF REDUNDANT ALKALI PREPARATION UNITS =    1
```

NEW PREMISES
500 MW
LIME WET SCRUBBING

```
SCRUBBER SYSTEM VARIABLES
-------- ------ ---------

NUMBER OF OPERATING SCRUBBING TRAINS =   4

NUMBER OF REDUNDANT SCRUBBING TRAINS =   1

NUMBER OF BEDS =   3

NUMBER OF GRIDS =   4

HEIGHT OF SPHERES PER BED =  5.0 INCHES

LIQUID-TO-GAS RATIO =  55. GAL/1000 ACF(SATD)

SCRUBBER GAS VELOCITY = 12.5 FT/SEC

INDUCED DRAFT SCRUBBER FAN OPTION

SCRUBBER PRESSURE = 14.7 PSIA

STOICHIOMETRY =  1.25 MOLE CAO ADDED AS LIME
                      PER MOLE (SO2+2HCL) ABSORBED

SCRUBBER INLET LIQUOR PH =  7.00

SO2 EMISSION LIMIT = 0.60 LB SO2/M BTU

ENTRAINMENT LEVEL = 0.10 WT %

EHT RESIDENCE TIME =  12.0 MIN

SO2 OXIDIZED IN SYSTEM =  30.0 PERCENT

SOLIDS IN RECIRCULATED SLURRY =  15.0 WT %


SOLIDS DISPOSAL SYSTEM
------ -------- ------

COST OF LAND =  5000.00 DOLLARS/ACRE

SOLIDS IN SYSTEM SLUDGE DISCHARGE =  40.0 WT %

MAXIMUM POND AREA =  9999. ACRES

MAXIMUM EXCAVATION =  25.00 FT

DISTANCE TO POND =  5280. FT

POND LINED WITH 12.0 INCHES CLAY


STEAM REHEATER (IN-LINE)
----- -------- ---------

SATURATED STEAM TEMPERATURE =  470. DEG F

HEAT OF VAPORIZATION OF STEAM =  751. BTU/LB

OUTLET FLUE GAS TEMPERATURE = 175. DEG F
```

NEW PREMISES
500 MW
LIME WET SCRUBBING

```
SUPERFICIAL GAS VELOCITY (FACE VELOCITY) =  25.0 FT/SEC

 500.0000****************        44.4896    11700.0000
```

NEW PREMISES
500 MW
LIME WET SCRUBBING

```
EXAMPLE CASE NEW PRMNSIS LIME                                            CASE 004

                         *** OUTPUTS ***

HOT GAS TO SCRUBBER
--- --- -- --------

          MOLE PERCENT      LB-MOLE/HR      LB/HR

CO2          12.338         0.2255E+05      0.9923E+06
HCL           0.006         0.1145E+02      0.4175E+03
SO2           0.214         0.3914E+03      0.2508E+05
O2            5.560         0.1016E+05      0.3251E+06
N2           75.227         0.1375E+06      0.3852E+07
H2O           6.654         0.1216E+05      0.2191E+06

SO2 CONCENTRATION IN SCRUBBER INLET GAS = 2142. PPM
                                        = 5.28 LBS / MILLION BTU

FLYASH EMISSION =  0.03 LBS/MILLION BTU
                =  0.015 GRAINS/SCF (WET)  OR    167. LB/HR

        SOLUBLE CAO IN FLY ASH =     0. LB/HR
        SOLUBLE MGO IN FLY ASH =     0.

HOT GAS FLOW RATE =  .1134E+07 SCFM (60 DEG F, 14.7 PSIA)
                  =  .1687E+07 ACFM (300. DEG F, 14.7 PSIA)

CORRESPONDING COAL FIRING RATE =  .4060E+06 LB/HR

HOT GAS HUMIDITY =  0.042 LB H2O/LB DRY GAS

WET BULB TEMPERATURE = 124. DEG F


WET GAS FROM SCRUBBER
--- --- ---- --------

          MOLE PERCENT      LB-MOLE/HR      LB/HR

CO2          11.517         0.2246E+05      0.9884E+06
HCL           0.000         0.5726E+00      0.2088E+02
SO2           0.023         0.4449E+02      0.2850E+04
O2            5.183         0.1011E+05      0.3235E+06
N2           70.495         0.1375E+06      0.3852E+07
H2O          12.782         0.2493E+05      0.4491E+06

SO2 CONCENTRATION IN SCRUBBER OUTLET GAS =  228. PPM

FLYASH EMISSION =  0.02 LBS/MILLION BTU
                =  0.007 GRAINS/SCF (WET)  OR     74. LB/HR

TOTAL WATER PICKUP =  471.  GPM
           INCLUDING   11.2 GPM ENTRAINMENT.

WET GAS FLOW RATE =  .1232E+07 SCFM (60 DEG F, 14.7 PSIA)
                  =  .1384E+07 ACFM (124. DEG F, 14.7 PSIA)

WET GAS SATURATION HUMIDITY =  0.087 LB H2O/LB DRY GAS
```

NEW PREMISES
500 MW
LIME WET SCRUBBING

```
FLUE GAS TO STACK
---- --- -- -----

          MOLE PERCENT     LB-MOLE/HR      LB/HR

CO2          11.498        0.2246E+05     0.9884E+06
HCL           0.000        0.5726E+00     0.2088E+02
SO2           0.023        0.4449E+02     0.2850E+04
O2            5.175        0.1011E+05     0.3235E+06
N2           70.382        0.1375E+06     0.3852E+07
H2O          12.921        0.2524E+05     0.4547E+06

CALCULATED SO2 REMOVAL EFFICIENCY =  88.7 %

SPECIFIED  SO2 EMISSION =   0.60 POUNDS PER MILLION BTU

CALCULATED SO2 CONCENTRATION IN STACK GAS =     228. PPM

FLYASH EMISSION =  0.02 LBS/MILLION BTU
                =  0.007 GRAINS/SCF (WET)  OR     74. LB/HR

STACK GAS FLOW RATE =  .1234E+07 SCFM (60 DEG F, 14.7 PSIA)
                    =  .1507E+07 ACFM (175. DEG F, 14.7 PSIA)


STEAM REHEATER (IN-LINE)
----- -------- ---------

SUPERFICIAL GAS VELOCITY (FACE VELOCITY) =  25.0 FT/SEC

SQUARE PIPE PITCH = 2 TIMES ACTUAL PIPE O.D.

SATURATED STEAM TEMPERATURE =  470. DEG F

OUTLET FLUE GAS TEMPERATURE = 175. DEG F

REQUIRED HEAT INPUT TO REHEATER = 0.6954E+08 BTU/HR

STEAM CONSUMPTION = 0.9260E+05 LBS/HR


                                   HEAT TRANSFER
OUTSIDE PIPE    PRESSURE DROP,     COEFFICIENT,
DIAMETER, IN.   IN. H2O            BTU/HR FT2 DEG F
  1.00              0.70             0.2096E+02


                REHEATER          NUMBER OF
                OUTSIDE PIPE      PIPES PER     NUMBER OF
                AREA, SQ FT       BANK PER      BANKS (ROWS)
                PER TRAIN         TRAIN         PER TRAIN

INCONEL         0.1529E+04           91             4
CORTEN          0.1039E+04           91             3
TOTAL           0.2568E+04           91             7
```

NEW PREMISES
500 MW
Lime Wet Scrubbing

```
WATER BALANCE INPUTS
----- ------- ------

  RAINFALL(IN/YEAR)                    50.
  POND SEEPAGE(CM/SEC)*10**8           50.
  POND EVAPORATION(IN/YEAR)            32.



WATER BALANCE OUTPUTS
----- ------- -------

WATER AVAILABLE

  RAINFALL                            746. GPM           372601. LB/HR
  ALKALI                                3. GPM             1271. LB/HR
      TOTAL                           748. GPM           373873. LB/HR


WATER REQUIRED

  HUMIDIFICATION                      460. GPM           229999. LB/HR
  ENTRAINMENT                          11. GPM             5609. LB/HR
  DISPOSAL WATER                      175. GPM            87310. LB/HR
  HYDRATION WATER                      12. GPM             5903. LB/HR
  CLARIFIER EVAPORATION                 0. GPM                0. LB/HR
  POND EVAPORATION                    513. GPM           256151. LB/HR
  SEEPAGE                              93. GPM            46261. LB/HR

  TOTAL WATER REQUIRED               1263. GPM           631232. LB/HR

NET WATER REQUIRED                    515. GPM           257360. LB/HR
```

NEW PREMISES
500 MW
Lime Wet Scrubbing

```
SCRUBBER SYSTEM
-------- ------

TOTAL NUMBER OF SCRUBBING TRAINS (OPERATING+REDUNDANT) =  3

SO2 REMOVAL =  88.6 PERCENT

PARTICULATE REMOVAL IN SCRUBBER SYSTEM =  50.0 PERCENT

TCA PRESSURE DROP ACROSS  3 BEDS =  8.6 IN. H2O

TOTAL SYSTEM PRESSURE DROP = 14.7 IN. H2O

OVERRIDE TOTAL SYSTEM PRESSURE DROP = 20.0 IN. H2O

SPECIFIED   LIQUID-TO-GAS-RATIO    =  55. GAL/1000 ACF(SATD)

LIME ADDITION = 0.2543E+05 LB/HR DRY LIME

SPECIFIED  LIME STOICHIOMETRY        =  1.25 MOLE CAO ADDED AS LIME
                                           PER MOLE (SO2+2HCL) ABSORBED

SOLUBLE CAO FROM FLY ASH =  0.0  MOLE PER MOLE (SO2+2HCL) ABSORBED

TOTAL SOLUBLE MGO         =  0.0  MOLE PER MOLE (SO2+2HCL) ABSORBED

TOTAL STOICHIOMETRY       =  1.25 MOLE SOLUBLE (CA+MG)
                                  PER MOLE (SO2+2HCL) ABSORBED

SCRUBBER INLET LIQUOR PH =  7.00

MAKE UP WATER =  515. GPM

CROSS-SECTIONAL AREA PER SCRUBBER =   461. SQ FT

SYSTEM SLUDGE DISCHARGE
------ ------ ---------
                                                SOLID    LIQUID
                                                COMP.    COMP.
SPECIES           LB-MOLE/HR     LB/HR          WT %     PPM

CASO3 .1/2 H2O    0.2428E+03     0.3135E+05     53.39
CASO4 .2H2O       0.1031E+03     0.1775E+05     30.23
CACO3             0.8808E+02     0.8817E+04     15.02
INSOLUBLES        ----------     0.7982E+03      1.36
H2O               0.4846E+04     0.8731E+05
CA++              0.6593E+01     0.2643E+03              3001.
MG++              0.0            0.0                        0.
SO3--             0.1417E+00     0.1135E+02               129.
SO4--             0.9982E+00     0.9589E+02              1089.
CL-               0.1088E+02     0.3857E+03              4379.


TOTAL DISCHARGE FLOW RATE = 0.1468E+06 LB/HR
                          =   221.     GPM

TOTAL DISSOLVED SOLIDS IN DISCHARGE LIQUID =   8584. PPM

DISCHARGE LIQUID PH =  7.33
```

NEW PREMISES
500 MW
Lime Wet Scrubbing

```
SCRUBBER SLURRY BLEED
-------- ------ -----

SPECIES             LB-MOLE/HR    LB/HR

CASO3 ,1/2 H2O      0,2428E+03    0,3135E+05
CASO4 ,2H2O         0,1031E+03    0,1775E+05
CACO3               0,8808E+02    0,8817E+04
INSOLUBLES          ----------    0,7982E+03
H2O                 0,1831E+05    0,3298E+06
CA++                0,2491E+02    0,9983E+03
MG++                0,0           0,0
SO3--               0,5355E+00    0,4287E+02
SO4--               0,3771E+01    0,3622E+03
CL-                 0,4110E+02    0,1457E+04
AD=                 0,0           0,0

TOTAL FLOW RATE = 0,3914E+06 LB/HR
                =     711,     GPM


TOTAL SUPERNATE RETURN
----- --------- ------

SPECIES             LB-MOLE/HR    LB/HR

H2O                 0,1732E+05    0,3121E+06
CA++                0,2357E+02    0,9447E+03
MG++                0,0           0,0
SO3--               0,5067E+00    0,4057E+02
SO4--               0,3568E+01    0,3428E+03
CL-                 0,3889E+02    0,1379E+04
AD=                 0,0           0,0

TOTAL FLOW RATE = 0,3148E+06 LB/HR
                =     630,     GPM


SUPERNATE TO LIME SLAKER
--------- -- ---- ------

SPECIES             LB-MOLE/HR    LB/HR

H2O                 0,7753E+04    0,1397E+06
CA++                0,1055E+02    0,4228E+03
MG++                0,0           0,0
SO3--               0,2268E+00    0,1816E+02
SO4--               0,1597E+01    0,1534E+03
CL-                 0,1741E+02    0,6170E+03
AD=                 0,0           0,0

TOTAL FLOW RATE = 0,1409E+06 LB/HR
                =     282,     GPM


LIME SLURRY FEED
---- ------ ----

SPECIES             LB-MOLE/HR    LB/HR

CASO3 ,1/2 H2O      0,0           0,0
CASO4 ,2H2O         0,5118E-01    0,8809E+01
CA(OH)2             0,4395E+03    0,3257E+05
```

NEW PREMISES
500 MW
LIME WET SCRUBBING

```
SOLUBLE MGO        0.0            0.0
INSOLUBLES         ------------   0.7247E+03
H2O                0.7425E+04     0.1338E+06
CA++               0.1149E+02     0.4605E+03
MG++               0.0            0.0
SO3--              0.2268E+00     0.1814E+02
SO4--              0.1546E+01     0.1485E+03
CL-                0.1741E+02     0.6170E+03
AD-                0.0            0.0

TOTAL FLOW RATE = 0.1680E+06 LB/HR
                =     298.     GPM


SUPERNATE RETURN TO SCRUBBER OR EHT
--------- ------ -- -------- -- ---

SPECIES            LB-MOLE/HR   LB/HR

H2O                0.9571E+04   0.1724E+06
CA++               0.1302E+02   0.5219E+03
MG++               0.0          0.0
SO3--              0.2799E+00   0.2241E+02
SO4--              0.1971E+01   0.1894E+03
CL-                0.2149E+02   0.7617E+03
AD-                0.0          0.0

TOTAL FLOW RATE = 0.1739E+06 LB/HR
                =     348.     GPM


RECYCLE SLURRY TO SCRUBBER
------- ------ -- --------

SPECIES            LB-MOLE/HR   LB/HR

CASO3 .1/2 H2O     0.2600E+05   0.3356E+07
CASO4 .2H2O        0.1104E+05   0.1900E+07
CACO3              0.9431E+04   0.9440E+06
INSOLUBLES         ----------   0.8947E+05
H2O                0.1960E+07   0.3531E+08
CA++               0.2667E+04   0.1069E+06
MG++               0.0          0.0
SO3--              0.5733E+02   0.4590E+04
SO4--              0.4037E+03   0.3878E+05
CL-                0.6400E+04   0.1560E+06
AD-                0.0          0.0

TOTAL FLOW RATE = 0.4191E+08 LB/HR
                =  78111.      GPM
```

```
FLUE GAS COOLING SLURRY
---- --- ------- ------

SPECIES              LB-MOLE/HR    LB/HR

CASO3 .1/2 H2O       0.1891E+04    0.2441E+06
CASO4 .2H2O          0.8030E+03    0.1382E+06
CACO3                0.6859E+03    0.6866E+05
INSOLUBLES           ----------    0.6216E+04
H2O                  0.1426E+06    0.2568E+07
CA++                 0.1939E+03    0.7773E+04
MG++                 0.0           0.0
SO3--                0.4170E+01    0.3338E+03
SO4--                0.2936E+02    0.2821E+04
CL-                  0.3200E+03    0.1135E+05
AD=                  0.0           0.0

TOTAL FLOW RATE = 0.3048E+07 LB/HR
                =    5535.     GPM
```

NEW PREMISES
500 MW
Lime Wet Scrubbing

```
             EXAMPLE CASE NEW PREMSIS LIME                                         CASE 004

                                PARTICULATE REMOVAL INVESTMENT AND OPERATING COST
                                                         PARTICULATE EMISSION REGULATION (LB ASH/MILLION BTU):   0.03
  WPSUL CONTENT (%):           3.35                      FLUE GAS TEMPERATURE (COLD) (F):                       300.0
  ASH CONTENT (%):            15.10                      FLUE GAS TEMPERATURE (HOT) (F):                        700.0
  BTU RATING:                 11700                      COST OF ELECTRICITY ($/KWHR):                           0.03
  BOILER TYPE:                DRY PULVERIZED COAL        COST OF STEAM ($/THOUSAND LB):                          2.00
  NO. OF SCRUBBERS:               4                      FIRST YEAR CAPITAL CHARGE FACTOR:                      0.180
  SCRUBBER VELOCITY (FT/M):   750.0                      BAGHOUSE RATIO (OPER. SQ.FT./ACTUAL SQ.FT.):            0.80
  PLANT SIZE (MW):              500                      BAG COST ($/SQ.FT.):                                    0.70
  OPERATING HRS/YR:            4730                      BAG LIFE(YEARS):                                        3.00
  PUMPING RATE (GAL/1000 ACF): 20.00                     FLUE GAS REHEAT TEMPERATURE (F):                        175.
  SCA RATIO:                  1.300                      CHEMICAL ENGINEERING PLANT INDEX:                      265.0
    (ACTUAL SQ.FT./CALC. SQ.FT.)

                                                                               NEW PREMISES
                                                                               500 MW
                                                                               Lime Wet Scrubbing
                                         ELECTROSTATIC PRECIPITATORS

                                            COLD          HOT          BAGHOUSE FABRIC FILTERS      SCRUBBERS

  REQUIRED REMOVAL EFFICIENCY (%):         99.70         99.70               99.70                   99.70
  DRIFT VELOCITY (FT/M):                   27.19         20.00
  SPECIFIC COLLECTION AREA (SQ.FT./ACFM):  277.74        377.59
  COLLECTION AREA (SQ.FT.):              468576.7      972309.6            866133.3
  TOTAL CORONA POWER (KW):                 663.6        1012.8
  AUXILIARY POWER (KW):                    407.4         915.2
  FAN POWER (KW):                          264.0         403.0               490.2
  PUMP POWER (KW):                                                          1320.1                  16039.9
  TOTAL POWER (KW):                       1335.0        2331.0                                       3267.8
  OPERATING AIR/CLOTH RATIO:                                                1810.3                  19307.7
  INSTALLED AIR/CLOTH RATIO:                                                   2.4
  REQUIRED PRESSURE DROP (INCHES):           1.0           1.0                 1.9
  DIAMETER (FEET):                                                             5.0                     60.8
  REQUIRED REHEAT (BTU/HR):                                                                              30
  STEAM SUPPLY/YR (THOUSAND LB):                                                                 64268960.0
  INSTALLED COST (1979 DOLLARS):      $  6562679    $ 12176132                                     337769.0
  FIRST YEAR CAPITALIZED COST:        $  1183469    $  2195762          $ 16303550              $ 22732816
  ANNUAL POWER COST:                  $   183115    $   319737          $  2940073              $  4099484
  ANNUAL OPERATING AND                                                  $   248320              $  2648436
   MAINTENANCE COST (1979 DOLLARS):   $   112895    $   169411
  REPLACEMENT COST (1979 DOLLARS):                                      $    73728              $  1192909
  ANNUAL REHEAT COST:                                                   $   265128
                                                                                                $   675538


  TOTAL ANNUAL COST:                  $  1479479    $  2684910          $  3527249              $  8616367
  ANNUALIZED COST OF POWER(MILLS/KWHR):     0.63          1.14                1.49                    3.64
```

```
                    POND DESIGN
                    ---- ------

    OPTIMIZED TO MINIMIZE TOTAL COST PLUS OVERHEAD
```

NEW PREMISES
500 MW
Lime Wet Scrubbing

```
  POND DIMENSIONS
  ---- ----------

  DEPTH OF POND                 22.17 FT
  DEPTH OF EXCAVATION            4.10 FT
  LENGTH OF POND PERIMETER    14263.   FT
  LENGTH OF DIVIDER            2591.   FT
  LENGTH PERIMETER FENCE      15270.   FT

  AREA OF BOTTOM               1251.   THOUSAND YD2
  AREA OF INSIDE WALLS          148.   THOUSAND YD2
  AREA OF OUTSIDE WALLS         109.   THOUSAND YD2
  AREA OF RECLAIM STORAGE       108.   THOUSAND YD2
  AREA OF POND                 1397.   THOUSAND YD2
  AREA OF POND SITE            1727.   THOUSAND YD2
  AREA OF POND SITE             357.   ACRES

  VOLUME OF EXCAVATION         1883.   THOUSAND YD3
  VOLUME OF RECLAIM STORAGE     793.   THOUSAND YD3
  VOLUME OF SLUDGE TO BE       9802.   THOUSAND YD3
  DISPOSED OVER LIFE OF PLANT  6076.   ACRE FT


  POND COSTS (THOUSANDS OF DOLLARS)
  ---- ----- ---------- -- --------

                                LABOR    MATERIAL   TOTAL
                                -----    --------   -----

  CLEARING LAND                  578.                578.
  EXCAVATION                    4678.               4678.
  DIKE CONSTRUCTION             2355.               2355.
  LINING( 12. IN. CLAY)         1398.               1398.
  SODDING DIKE WALLS              94.       62.      156.
  ROAD CONSTRUCTION               40.       12.       53.
  PERIMETER COSTS, FENCE+         76.      153.      229.
  RECLAIMATION EXPENSE           954.                954.
  MONITOR WELLS                    4.        4.        8.
  ------------------------------------------------------
  POND CONSTRUCTION            10179.      231.    10409.
  LAND COST                                         1784.
  ------------------------------------------------------
  POND SITE                                        12193.
  OVERHEAD                                          8889.
  ------------------------------------------------------
  TOTAL                                            21082.
```

NEW PREMISES
500 MW
Lime Wet Scrubbing

RAW MATERIAL HANDLING AND PREPARATION

INCLUDING 2 OPERATING AND 1 SPARE PREPARATION UNITS

ITEM	DESCRIPTION	NO.	MATERIAL	LABOR
CONVEYOR FROM CALCINATION PLANT	1500FT HORIZONTAL, 30HP	1	177763.	31269.
STORAGE SILO ELEVATOR	105.FT HIGH, 50 HP	1	53741.	3214.
CONCRETE STORAGE SILO	76283.FT3,40.2FT DIA , 60.2FT STRAIGHT SIDE STORAGE HT	2	205763.	419981.
STORAGE SILO HOPPER BOTTOM	60 DEGREE, CS	2	25981.	17165.
RECLAIM VIBRATING FEEDER	3.5HP	2	6539.	648.
RECLAIM BELT CONVEYOR	155.FT HORIZONTAL, 5HP	1	25549.	3321.
FEED BIN ELEVATOR	50FT HIGH, 50HP	1	32370.	1836.
FEED BELT CONVEYOR	50FT HORIZONTAL, 5HP	1	10354.	864.
FEED CONVEYOR TRIPPER	30FPM, 1HP	1	16240.	5401.
FEED BIN	10FT DIA, 15FT STRAIGHT SIDE HT, COVERED, CS	3	12425.	8263.
BIN VIBRATING FEEDER	3.5HP	3	26158.	3240.
BIN WEIGH FEEDER	12FT, 12IN SCREW, 1HP	3	13406.	1944.
SLAKER	6.TPH, 11.HP	3	157694.	8912.
SLAKER PRODUCT TANK		3	13242.	10369.
SLAKER PRODUCT TANK AGITATOR	10HP	3	19618.	4536.
LIME SYSTEM DUST COLLECTORS	POLYPROPYLENE BAG TYPE 2200 CFM,7.5HP	5	33242.	11881.
SLAKER PRODUCT TANK SLURRY PUMPS	149.GPM, 60FT HEAD, 4.HP, 2 OPERATING AND 1 SPARES	3	10253.	3025.
SLURRY FEED TANK	157415.GAL, 29.9FT DIA, 29.9FT HT, FLAKEGLASS-LINED CS	1	33200.	26504.
SLURRY FEED TANK AGITATOR	54.HP	1	52939.	4197.
SLURRY FEED TANK PUMPS	75.GPM, 60 FT HEAD, 2.HP, 4 OPERATING AND 4 SPARE	8	26096.	5959.
			---------	---------
TOTAL EQUIPMENT COST			952573.	572529.

NEW PREMISES
500 MW
Lime Wet Scrubbing

SCRUBBING

INCLUDING 4 OPERATING AND 1 SPARE SCRUBBING TRAINS

ITEM	DESCRIPTION	NO.	MATERIAL	LABOR
I.D. FANS	20.0IN H2O, WITH 1580. HP MOTOR AND DRIVE	5	4408429.	61483.
SHELL			1311117.	
RUBBER LINING			1292106.	
MIST ELIMINATOR			267256.	
SLURRY HEADER AND NOZZLES			326007.	
GRIDS			579348.	
SPHERES			790198.	
TOTAL TCA SCRUBBER COSTS		5	4566029.	319715.
REHEATERS		5	2195402.	133789.
SOOTBLOWERS		60	252858.	151216.
EFFLUENT HOLD TANK	251165.GAL, 35.0FT DIA, 35.0FT HT, FLAKEGLASS-LINED CS	5	259720.	202782.
EFFLUENT HOLD TANK AGITATOR	66.HP	5	347575.	137781.
COOLING SPRAY PUMPS	1384.GPM 100FT HEAD, 64.HP, 4 OPERATING AND 6 SPARE	10	89717.	26703.
ABSORBER RECYCLE PUMPS	9514.GPM, 100FT HEAD, 441.HP, 8 OPERATING AND 7 SPARE	15	864979.	93017.
MAKEUP WATER PUMPS	2768.GPM, 200.FT HEAD, 233.HP, 1 OPERATING AND 1 SPARE	2	24254.	2644.
			---------	---------
TOTAL EQUIPMENT COST			13008947.	1129128.

WASTE DISPOSAL

ITEM	DESCRIPTION	NO.	MATERIAL	LABOR
ABSORBER BLEED RECEIVING TANK	62724.GAL, 17.5FT DIA, 35.0FT HT, FLAKGLASS-LINED CS	1	20681.	16524.
ABSORBER BLEED TANK AGITATOR	38.HP	1	23630.	1873.
POND FEED SLURRY PUMPS	711.GPM, 130.FT HEAD 43.HP, 1 OPERATING AND 1 SPARE	2	15227.	3992.
POND SUPERNATE PUMPS	630.GPM, 192.FT HEAD, 51.HP, 1 OPERATING AND 1 SPARE	2	11212.	1222.
TOTAL EQUIPMENT COST			70751.	23611.

LIME SLURRY PROCESS -- BASIS: 500 MW UNIT, 1981 STARTUP

PROJECTED CAPITAL INVESTMENT REQUIREMENTS - EXAMPLE CASE NEW PREMSIS LIME

NEW PREMISES
500 MW
Lime Wet Scrubbing

CASE 004

	INVESTMENT, THOUSANDS OF 1980 DOLLARS				DISTRIBUTION
	RAW MATERIAL HANDLING AND PREPARATION	SCRUBBING	WASTE DISPOSAL	TOTAL	PERCENT OF DIRECT INVESTMENT
EQUIPMENT					
MATERIAL	953.	13009.	71.	14032.	33.1
LABOR	573.	1129.	24.	1725.	4.1
PIPING					
MATERIAL	513.	3364.	872.	4749.	11.2
LABOR	231.	656.	289.	1176.	2.8
DUCTWORK					
MATERIAL	0.	2297.	0.	2297.	5.4
LABOR	0.	1853.	0.	1853.	4.4
FOUNDATIONS					
MATERIAL	74.	136.	17.	227.	0.5
LABOR	150.	285.	34.	469.	1.1
POND CONSTRUCTION	0.	0.	10409.	10409.	24.5
STRUCTURAL					
MATERIAL	109.	287.	2.	398.	0.9
LABOR	88.	483.	3.	574.	1.4
ELECTRICAL					
MATERIAL	113.	715.	126.	954.	2.2
LABOR	248.	1312.	266.	1825.	4.3
INSTRUMENTATION					
MATERIAL	128.	632.	9.	769.	1.8
LABOR	18.	102.	8.	128.	0.3
BUILDINGS					
MATERIAL	0.	0.	0.	0.	0.0
LABOR	0.	0.	0.	0.	0.0
SERVICES AND MISCELLANEOUS	66.	543.	251.	860.	2.0
SUBTOTAL DIRECT INVESTMENT	3261.	26803.	12380.	42444.	100.0
ENGINEERING DESIGN AND SUPERVISION	294.	2412.	1114.	3820.	9.0
CONSTRUCTION EXPENSES	522.	4288.	1981.	6791.	16.0
CONTRACTOR FEES	163.	1340.	619.	2122.	5.0
CONTINGENCY	848.	6969.	3219.	11035.	26.0
SUBTOTAL FIXED INVESTMENT	5088.	41812.	19313.	66212.	156.0
ALLOWANCE FOR STARTUP AND MODIFICATIONS	391.	3216.	1486.	5093.	12.0
INTEREST DURING CONSTRUCTION	763.	6272.	2897.	9932.	23.4
SUBTOTAL CAPITAL INVESTMENT	6242.	51300.	23696.	81237.	185.4
LAND	15.	4.	1796.	1815.	4.3
WORKING CAPITAL	184.	1509.	697.	2390.	5.6
TOTAL CAPITAL INVESTMENT	6441.	52813.	26189.	85442.	201.3

```
     LIME SLURRY PROCESS -- BASIS: 500 MW UNIT, 1981 STARTUP
PROJECTED REVENUE REQUIREMENTS - EXAMPLE CASE NEW PREMSIS LIME
                                                                                              CASE 004
                                             DISPLAY SHEET FOR YEAR=   1
                                           ANNUAL OPERATION KW-HR/KW =  4730

                              29.36 TONS PER HOUR                             DRY          SLUDGE
                                         TOTAL CAPITAL INVESTMENT         82896000                 TOTAL
                                                                                                   ANNUAL
                                                     ANNUAL QUANTITY       UNIT COST,$              COST,$
         DIRECT COSTS                                ---------------       -----------              ------
         ------------
           RAW MATERIAL
           ------------
            LIME                                       60.1 K TONS        40.00/TON               2405400
                                                                                                ---------
               SUBTOTAL RAW MATERIAL                                                             2405400
           CONVERSION COSTS
           ----------------
             OPERATING LABOR AND
               SUPERVISION                             28450.0 MAN-HR      12.50/MAN-HR            355600
             UTILITIES
               STEAM                                  438010.0 K LB         2.00/K LB              876000
               PROCESS WATER                          146140.0 K GAL        0.12/K GAL              17500
               ELECTRICITY                          39498880.0 KWH          0.029/KWH             1145500
             MAINTENANCE
               LABOR AND MATERIAL                                                                 2875100
             ANALYSES                                   4590.0 HR          17.00/HR                 77900
                                                                                                ---------
               SUBTOTAL CONVERSION COSTS                                                         5347600

               SUBTOTAL DIRECT COSTS                                                             7753000
         INDIRECT COSTS
         --------------
           OVERHEADS
             PLANT AND ADMINISTRATIVE (  60.0% OF CONVERSION COSTS LESS UTILITIES)               1985200
                                                                                                ---------
           FIRST YEAR OPERATING AND MAINTENANCE COSTS                                            9738200
           LEVELIZED CAPITAL CHARGES( 14.7% OF TOTAL CAPITAL INVESTMENT)                        12560000
                                                                                                ---------
               FIRST YEAR ANNUAL REVENUE REQUIREMENTS                                           22298200

               EQUIVALENT FIRST YEAR UNIT REVENUE REQUIREMENTS, MILLS/KWH                          9.43
-------------------------------------------------------------------------------------------------------------
           LEVELIZED OPERATING AND MAINTENANCE ( 1.886 TIMES FIRST YEAR OPER. & MAIN.)         18366200
           LEVELIZED CAPITAL CHARGES( 14.7% OF TOTAL CAPITAL INVESTMENT)                        12560000
                                                                                                ---------
               LEVELIZED ANNUAL REVENUE REQUIREMENTS                                            30926200

               EQUIVALENT LEVELIZED UNIT REVENUE REQUIREMENTS, MILLS/KWH                          13.08
-------------------------------------------------------------------------------------------------------------
           HEAT RATE   9500. BTU/KWH    -    HEAT VALUE OF COAL    11700 BTU/LB    -    COAL RATE    960100 TONS/YR
```

NEW PREMISES
500 MW
Lime Wet Scrubbing

PEDCO ENVIRONMENTAL, INC., INVESTMENT/COSTS

(MID-1980 DOLLARS)

LIME FGD
CAPITAL INVESTMENT
500 MW,3.48% S.90%

LIME PREPARATION	EQUIPMENT COST, $	
CONVEYORS	546000.	
SLAKERS AND PUMPS	161000.	
STORAGE SILOS	1249000.	
STORAGE TANKS	261000.	
PUMPS AND MOTORS	36000.	
	SUB TOTAL - LIME PREP	2253000.
SO 2 SCRUBBING		
ABSORBERS	15973000.	
FANS AND MOTORS	2040000.	
HEAT EXCHANGERS	3100000.	
SOOT BLOWERS	1196000.	
VALVES AND DUCTING	1617000.	
MOLD TANKS	1037000.	
PUMPS AND MOTORS	2982000.	
	SUB TOTAL - SO2 SCRUB	27945000.

CAPITAL INVESTIMENT (CONTD)

SLUDGE DISPOSAL		
CLARIFIERS	986000.	
VACUUM FILTERS	0.	
CHEMICAL STORAGE	44000.	
MOBILE EQUIPMENT	62000.	
TANKS AND AGITATORS	95000.	
PUMPS AND MOTORS	245000.	
	SUB TOTAL - SLUDGE DISP	1432000.
	TOTAL INSTALLED COST	31630000.
	RAW MATL INVENTORY (working cap)	304000.
	SLUDGE POND	7986000.

DI = total installed cost + sludge pond

```
                  CAPITAL INVESTMENT (CONTD)

INDIRECT COSTS

  INTEREST DURING CONSTRUCTION              3962000.
  FIELD OVERHEAD                            3962000.
  ENGINEERING                               3163000.
  FREIGHT                                    395000.
  OFFSITE                                   1188000.
  TAXES                                      474000.
  SPARES                                     158000.
  ALLOWANCE FOR SHAKEDOWN                   1996000.
                                              TOTAL INDIRECT COST       15298000.
                                            CONTINGENCY                 11044000.
                                            CONTRACTOR FEE               3313000.
                                            LAND COST                     154000.

                                            - - - - - - - - - - - - - - - - - - - - -

                                            TOTAL CAPITAL INVESTMENT    69729000.
                                            TOTAL INVESTMENT PER KW       139.46

                                            - - - - - - - - - - - - - - - - - - - - -
```

LIME FGD
OPERATING COST
500 MW,3.48% S.90% REG

	QUANTITY	RATE	ANNUAL COST, $
RAW MATERIAL			
LIME	11.3 TON/HR	$ 50.00 /TON	3219000.
FIXATION CHEMICAL	4.6 TON/HR	$ 20.00 /TON	527000.
UTILITIES			
WATER	591.9 GPM	$ 0.200 /kgal	32000.
ELECTRICITY	16711.6 KW	$ 25.00 MILLS/KWH	1903000.
REHEAT	92.0 MMBTU/HR	$ 1.25 /MMBTU	524000.
LABOR			
DIRECT LABOR	76.00 MANHR/DAY	$ 10.00 /MANHR	277000.
SUPERVISION	15 % OF DIRECT LABOR		42000.
MAINTENANCE			
LABOR AND MATERIAL	4.35 % OF TOTAL CAPITAL INVESTMENT		2889000.
SUPPLIES	15 % OF LABOR AND MATERIAL		433000.
OVERHEAD			
PLANT	50 % OF OPERATING LABOR AND MAINT		1821000.
PAYROLL	20 % OF OPERATING LABOR		64000.
SLUDGE HANDLING	264000. TON-MILE/YR	$ 2.00 /TON-MILE	528000.
		SUB TOTAL - OPERATING AND MAINTENANCE	12259000.